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THE ABT RACK RAILWAY.

THE Société des Anciens Etablissements Cail, desirous of obtaining the right of construction of the best type of rack railway known, has, after examination, made a contract with Mr. Abt for the exclusive exploitation of his patents in France.

As well known, the first idea of rack locomotives, carried out by Blenkinsop in 1841, was soon abandoned after the experiments of Stephenson upon adhesion. It required nearly fifty years to obtain a just appreciation of the advantages to be derived from the rational application of one or the other principle.

The extension of communication by railways quickly led engineers to turn their attention to mountainous countries, where the constructive works so greatly increase the cost of the first establishment, and to endeavor to effect a saving in the cost of construction by the adoption of engines capable of ascending gradients greater than 30 millimeters to the meter. So a return to the rack was indicated, with the following advantages: (1) The possibility of adopting a profile with steep declivities, without being obliged to diminish the load to be hauled; (2) a saving in the establishment through a reduction of the constructive works and of the length of the line, whence results, besides, the advantage of rapidity of execution; (3) a reduction in the expense of exploitation, since, without breaking bulk, it is possible to haul trains much heavier than those that adhesion alone would permit of.

The efficiency of the principle became evident after several experiments that were crowned with success, and among which we shall mention merely the Righi railway. Mr. Abt made a special study of the problem, and obtained a solution that in 1888 gained for him the grand prize of 7,500 marks of the Union of German Railways.

Let us briefly recall the principle of it: A line with ordinary adhesion rails, with an axial rack consisting of several toothed bars of rolled soft steel established vertically alongside of each other so that the teeth overlap (number and thickness of the racks variable, according to the profile of the line); a locomotive provided with two independent motive mechanisms, one of which, an adhesion mechanism, operates continuously, while the other acts only where the racks exist, and simultaneously with the other. The toothed wheels are formed of as many toothed disks as there are racks on the road bed, and are carried by axles that are so spaced that the attacks shall be successive. If there are two axles, the spacing will, therefore, be equal to N + ½ length of the pitch; if there are three axles, it will be N + ⅓. As, on another hand, the teeth overlap, four attacks per pitch will be produced for two racks and two axles, whence a very great smoothness in the running. It has thus been possible to adopt a pitch of 120 millimeters. A special piece permits a train to pass insensibly from an adhesion to a rack portion.

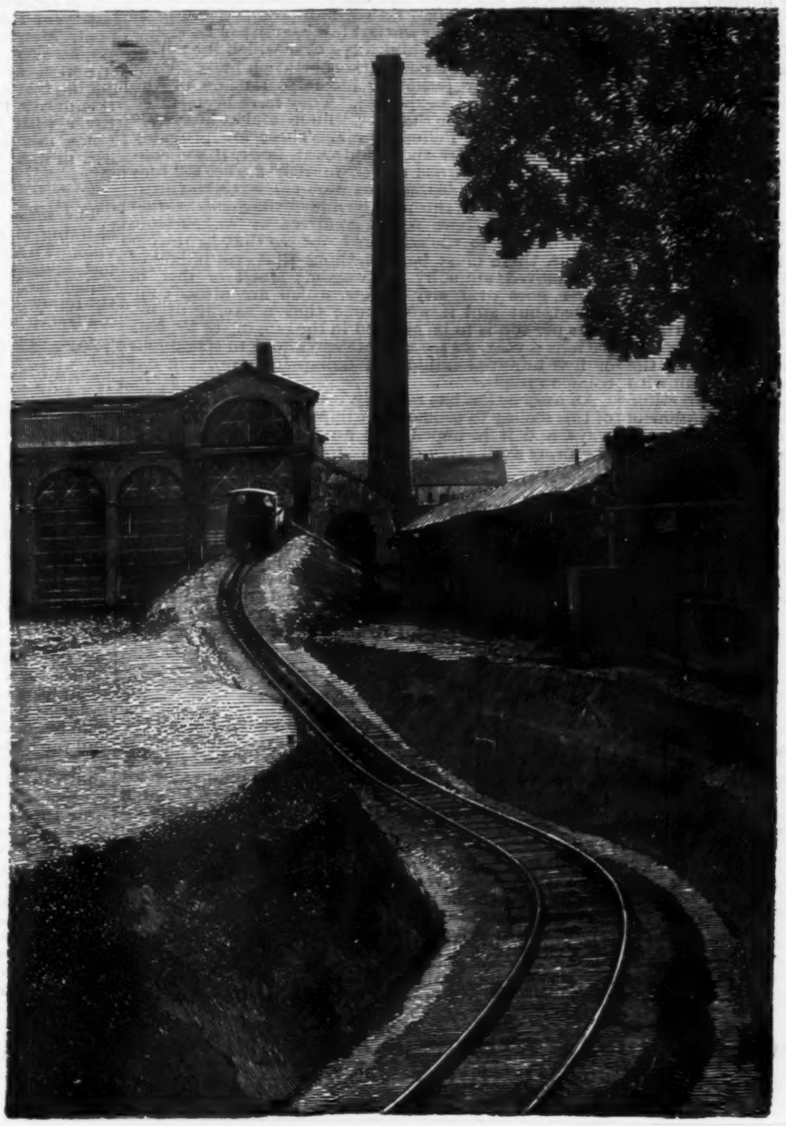


FIG. 2.—EXPERIMENTS WITH A RACK LOCOMOTIVE AT THE CAIL ESTABLISHMENT.

FIG. 1.—ABT SYSTEM OF RACK LOCOMOTIVE.

Finally, a very powerful compressed air brake is made to act upon the system when necessary, and consists in a reversal of motion after substituting for the entrance of steam a flow of external air, which is cooled during the compression by an injection of water.

It is not without interest to recapitulate the principal applications of the Abt system.

1. *Harz Line* (Brunswick).—This is a 30·5 kilometer line, including 7 kilometers of rack, distributed over eleven sections varying from 250 to 1,550 meters; gradients of 45 to 60 millimeters, with curves of 250 meters minimum radius. The rack is of three bars, 20 millimeters in thickness, 110 in height, and 35 millimeters apart. There are three driving axles, and the weight hauled is from 120 to 135 tons at 10 kilometers per hour upon slopes of 60 millimeters.

The line has been in operation since 1885.

2. *Exploitation of the Iron Mines of Erzberg* (Austria).—This line is 20 kilometers in length, 14·5 kilometers of which are provided with racks. The gradients are 71 millimeters in a straight line and 65 in curves of 180 meters radius. The axles are three in number. The weight hauled is from 100 to 120 tons at a minimum.

3. *Line from Viege to Zermatt* (designed for tourists).—This line is provided with a track of one meter gauge. Two racks from 20 to 25 millimeters in thickness follow the profile. The driving axles are two in number. The gradients are of 125 millimeters, which are ascended by trains of 45 tons. The curves have a radius of 60 meters.

4. *Mendozza to Santa Rosa* (South America).—In course of construction, and to be finished in 1892. The length of the mountain portion is 104 kilometers, 28 kilometers of which are provided with racks. The track is of one meter gauge, the gradients are of 80 millimeters, and the curves are of 115 meters radius.

5. *Line from Diacophto to Kalavryta* (Greece).—Track of 0·75 meter gauge, with gradients of 145 millimeters, and curves of 80 meters. The racks are two and the axles three in number, and the load hauled is 15 tons at 15 kilometers per hour over adhesion gradients of 35 millimeters and from 5 to 10 tons over rack gradients of 145 millimeters. The road is under partial exploitation.

6. *State Railways of Bosnia and Herzegovina.*—Length 68 kilometers, 19·5 of which are rack in six sections. Gradients from 30 to 60 millimeters. Racks two, axles three. Each locomotive hauls a 70 ton train over 60 millimeter gradients; exploitation begun, road to be completed this year.

7. *Central Dominican, of Puerto Plata, Saint Domingo.*—In course of construction at present to Santiago. The gradients are of 90 millimeters, with curves of 100 meters radius. The track is 0·76 meter gauge. The weight hauled is 50 tons at 15 kilometers over gradients of 40 milli-

meters and at 7 kilometers over gradients of 90 millimeters.

8. *Monte Generoso (Switzerland), for Tourists Solely.*—Nine kilometers of rackway. Gauge 0·8 meter; gradients of from 0 to 220 millimeters; curves 60 meters; racks 2; axles 2. Each engine hauls one car with 56 travelers.

9. *Rothhorn.*—Like the preceding.

10. *Glion Railway.*—Like the two preceding.

11. *Puerto Cabello, at Valencia (Venezuela).*—Track, one meter gauge; gradients, 80 millimeters; curves, 115 meters radius; racks 3, axles 2; weight hauled over gradients of 80 millimeters, 60 tons.

12. *Railway from Manitou to Pike's Peak* (U. S.)—Remarkable by its situation. A tourist's road having its starting station at an altitude of 2,000 meters and its terminus at 4,320—720 meters above all vegetation. This is a 14·5 kilometer line wholly of racks. The gradients are from 0 to 250 millimeters; the curves are of 112 meters radius; the racks are 2 in number and the axles 3. The mean speed is 8 and the minimum 5 kilometers.

13. *The Mount Salere Railway.*—Gauge, 1 meter; gradients, 250 milimeters; curves, 60 meters radius; length, 9 kilometers; racks, 2.

14. *Line from Aix-les-Bains to Revard.*—This will be the first mountain railway inaugurated in France. It will be opened in June, 1892. Gauge, 1 meter; length, 9·2 kilometers, all rackway. Each locomotive will haul 1 car with 60 passengers.

15. *Line from Veyrier to the Peaks of Mount Salere.*—This line is not yet begun.

16. *Line from Cluses to Martigny, through Chamounix.*—This is a line authorized by a very recent law, and the work on it will be begun without delay.

From this rapid *exposé* it may be seen that the question of rack railways has assumed a great importance. The Abt system has already in service, or in course of construction, an extent of 400 kilometers of track, 196 of which are provided with racks.

It will be conceived, then, with what eagerness the Societe Anonyme des Anciens Etablissements Cail, with its complete equipments and its intelligent direction, sought to secure the monopoly of the exploitation of this system in France. The lines designated by the numbers 5, 7, 14, 15, and 16 have been, or are to be, established by it.—*Le Genie Civil.*

PASSAGES OF ATLANTIC PASSENGER STEAMERS.

IN SUPPLEMENT No. 811 we gave a table of the voyages of the prominent steamers running between New York and Queenstown for the season of 1890. We now present a corresponding table, for which we are indebted to *Engineering*, for the steamers plying between New York and Southampton.

BEST VOYAGE OF HAMBURG-AMERICAN LINERS FROM SOUTHAMPTON TO NEW YORK, 1890–91.

Date.	Name of Steamer.	Duration of Voyage. d. h. m.	Total Knots Steamed.	Knots per Hour.	Best Day's Run.
May, 1891	Furst Bismarck	6 14 15	3086	19·5	498
June, 1890	Columbia	6 16 23	3050	19·01	492
Aug., 1890	Normannia	6 17 2	3045	18·91	486
Oct., 1890	Augusta-Victoria	6 22 48	3047	18·27	472
FROM NEW YORK TO SOUTHAMPTON.					
May, 1891	Furst Bismarck	6 13 25	3114	19·78	472
Oct., 1890	Columbia	6 15 0	3045	19·15	463
Nov., 1890	Normannia	6 17 3	3046	18·92	453
Sept., 1890	Augusta-Victoria	6 22 32	3049	18·31	438

[Continued from SUPPLEMENT, No. 814, page 13005.]

LEADING ENGINEERING WORKS OF THE PAST YEAR.*

By O. CHANUTE, President Am. Soc. C. E.

COMMON ROADS.

WITHIN the last few years increased attention has been given to the economies to be effected by improving the condition of our highways and ordinary country roads, and several States are now considering as to the best means of inaugurating the improvement of common roads. Hitherto there was a lesser necessity for such improvement. The great savings were to be effected upon transportation to distant markets, and as capital was scanty in the first settlement of the country, we devoted our first attention to the utilization of the rivers, and next to the building of railroads. In pursuing this course the people have acted wisely, but now the time has come when further savings to the farmers (who have had rather hard competition from foreign sources during the last few years) can be effected by improving the highways over which they haul their produce to the main transportation lines. Various fragmentary estimates have been made of the annual saving to be expected. They have been stated at $15,000,000 for the State of Illinois and at $6,000,000 for the State of Pennsylvania. These are probably overestimates. For the country at large, if we consider that the railroad moved in 1889 619,530,653 tons of freight, that 27,460,260 tons were moved on the great lakes, and that to this is to be added the goods carried on rivers, and those which go direct by wagon from the producer to the consumer, we see that in the aggregate there must be something like one billion of tons moved annually by wagon. Much of this, of course, goes over city streets, which are already improved, but still if we assume that a saving of ten cents per ton is to be effected in the moving of 250,000,000 tons a year, we see that we can afford to spend four or five hundred millions of dollars in improving our common roads.

An association has recently been formed of members of this society to promote the improvement of the highways, and it is hoped that an increasing number of engineers shall give attention to the subject.

METALLURGY.

The year 1890 was notable in metallurgy as being the first in which our production of iron and steel was greater than that of any other nation. No less than 10,307,028 net tons of pig iron were produced; 2,804,829 tons of rolled iron; 2,091,978 tons of Bessemer steel rails, and 1,829,247 tons of rolled steel. Much of the consumption is doubtless owing to the increasing use of iron and steel for structural purposes, and similar engineering works.

BRIDGES.

THE RED ROCK BRIDGE.

One of the important bridges completed during the past year was the Red Rock cantilever bridge across the Colorado River where it forms the dividing line between Arizona and California, some 13 miles below the point known as "The Needles," where stood a former bridge on the Atlantic and Pacific Railroad which is replaced by the new structure. The latter is remarkable as being the longest cantilever bridge in the United States, the center opening being 660 feet, while the length over all is 990 feet. Thus each anchor arm is 165 feet, the lever arm being of the same length, and the suspended span is 330 feet long, these proportions, which are not those of maximum economy of superstructure, being dictated by the character of the river bottom. The iron and steel in the structure weigh 1,750 tons, and the erection was done with a traveler of original type which ran on tracks at the same level as the base of the rail, and inside of the trusses; its top extending some 10 feet above the highest point of the truss, and its forward portion projecting about two panel lengths ahead of the front supporting wheels. The erection was begun February 4, 1890, and completed in eighty working days, and trains were running over the bridge May 10 of the same year. The structure is proportioned for the heavy live loads as now specified for all important bridges. The chief engineer was Mr. S. M. Rowe, member of this society, who intends, I believe, to give us a full descriptive paper upon this bridge; and the superstructure was designed, manufactured and erected by the Phœnix Bridge Company.

* Address at the annual convention of the American Society of Civil Engineers, at Chattanooga, Tenn., May 22, 1891.

ST. LOUIS ELEVATED RAILWAY.

The same bridge company also completed during the last year the Terminal Elevated Railway for the St. Louis Merchants' Bridge. This is one of the best examples of modern double track elevated railway construction at the present time. The structure is for double track, is 1½ miles long, and weighs 5,000 tons. It connects the Merchants' Bridge over the Mississippi River with the terminal at the Union Station at St. Louis, and is proportioned for the heaviest live loads now in use.

OHIO RIVER BRIDGE AT LOUISVILLE.

The same bridge company is now engaged in the building of a bridge across the Ohio River at Louisville. This structure has a total length of about 9,206 feet, consisting of an iron viaduct on the Indiana side, called the Jeffersonville approach, 4,063 feet long, then the following river spans: one span 210 feet; three spans 555 feet center to center of piers; two spans 341 feet, and an approach on the Louisville, Kentucky, side of 2,586 feet. The bridge is for single track, and the weight of the iron and steel is about 12,000,000 pounds. It is expected that the structure will be completed by the end of the present year.

WHEELING BRIDGE.

The Wheeling Bridge and Terminal Railway Bridge, over the Ohio River at Wheeling, W. Va., was built in 1890, by the Edge Moor Bridge Works, for the Wheeling Bridge and Terminal Railway, under the supervision of Mr. Job Abbott, chief engineer of the Wheeling Bridge and Terminal Railway, and member of this society. The total length of the bridge is about 2,100 feet, consisting of one 525 feet span, three 250 feet spans, one 150 feet span, one 108 feet span, all pin connected, three lattice girder spans of about 100 feet, and 317 feet of viaduct of 33 feet spans generally. The entire structure is for double track railway, and was designed for a load of two 104 ton engines followed by a train load of 3,000 pounds per foot. The material is mild steel, of which there was 9,000,000 pounds used. The main channel span is 518 feet center to center of end pins, and 80 feet deep center to center of chords. The style of truss used is what is known as the curved chord Pratt. The shoes of this span rest on heavy steel girders, 40 feet long and 5 feet deep, designed to distribute the enormous weight over the tops of the piers. This span weighs 4,000,000 pounds, including the pier girders, which (on the basis of the dead load given on the lithographic stress sheets for the 550 feet span of the Cincinnati bridge) makes this the heaviest truss span yet built in America. The viaduct at the Martin's Ferry end of this bridge was built over a street, which necessitated leaving out all transverse sway bracing between the columns. The columns were made stiff enough to transmit the wind and centrifugal forces to the masonry.

PASSAGES OF PRINCIPAL ATLANTIC PASSENGER STEAMERS (SOUTHAMPTON AND NEW YORK), SEASON 1890.

[SPECIALLY COMPILED FROM OFFICIAL LOGS.]

NAME	"COLUMBIA."	"NORMANNIA."	"AUGUSTA VICTORIA."	"LAHN."
Owners	HAMBURG-AMERICAN LINE.	HAMBURG-AMERICAN LINE.	HAMBURG-AMERICAN LINE.	NORTH GERMAN LLOYD.
Builders	Messrs. Laird Brothers, Birkenhead.	Fairfield Company, Govan.	The Vulcan Company, Stettin.	Fairfield Company, Govan.
Dimensions	480 ft. by 56 ft. by 38 ft.	520 ft. by 57½ ft. by 38 ft.	480 ft. by 56 ft. by 33 ft.	448 ft. by 49 ft. by 36¾ ft.
Tonnage	7578	8716	7661	5661
Displacement	9500	10,500	9500	7700
Cylinders	Two 41 in., two 66 in., two 101 in.	Two 40 in., two 67 in., two 106 in.	Two 41$\frac{6}{16}$ in., two 66$\frac{11}{16}$ in., two 100$\frac{5}{16}$ in.	Two 3?½ in., one 68 in., two 85 in.
Piston stroke	66 in.	66 in.	63 in.	72 in.
Boiler heating surface	34,916 sq. ft.	46,490 sq. ft.	36,000 sq. ft.	—
Grate area	1220 "	1452 "	1120 "	—
Steam pressure	150 lb.	160 lb.	150 lb.	150 lb.
I. H. P.	13,680	16,352	14,110	9500

Details of westward passages—to New York.

Columbia Month.	Time.	Distance.	Average Speed per Hour.	Normannia Month.	Time.	Distance.	Average Speed per Hour.	Augusta Victoria Month.	Time.	Distance.	Average Speed per Hour.	Lahn Month.	Time.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots		d. h. m.	knots	knots		d. h. m.	knots	knots		d. h. m.	knots	knots
April	7 9 49	3059	17.2	May	6 21 50	3060	18.46	April	7 9 0	3052	17.24	May	7 8 0	—	—
May	6 22 30	3088	18.6	June	7 3 0	3139	18.31	May	7 18 4	3062	16.43	June	7 12 0	—	—
June	6 16 23	3050	19.1	July	7 1 30	3141	18.53	June	7 14 7	3125	17.16	July	7 10 0	—	—
July	6 21 0	3109	18.94	August	6 17 2	3045	18.91	July	7 6 20	3109	17.83	August	7 8 0	—	—
August	6 18 4	3044	18.8	September	6 19 0	3079	18.89	August	7 4 24	3078	17.84	September	7 7 0	—	—
September	6 19 45	3044	18.6	October	6 21 0	3055	18.52	September	6 22 54	3041	18.22	October	7 23 0	—	—
October	6 21 35	3041	18.36	November	7 21 27	3083	16 27	October	6 22 43	3047	16.28	November	7 11 0	—	—
"	6 23 36	3044	18.17					November	7 19 13	3047	16.28	December	7 15 0	—	—
Average	6 22 5	—	18.46	Average	7 1 15	—	18.27	Average	7 7 23	—	17.16	Average	7 11 45	—	17.13
Best day's run, 492 knots in June.				Best day's run, [illegible] knots in August.				Best day's run, 470 knots in September.							

Details of eastward passages—to Queenstown.

Columbia Month.	Time.	Distance.	Average Speed per Hour.	Normannia Month.	Time.	Distance.	Average Speed per Hour.	Augusta Victoria Month.	Time.	Distance.	Average Speed per Hour.	Lahn Time.	Month.	Distance.	Average Speed per Hour.
	d. h. m.	knots	knots		d. h. m.	knots	knots		d. h. m.	knots	knots		d. h. m.	knots	knots
April	6 20 43	3057	18.56	June	7 2 0	3144	18.49	May	7 2 21	3072	18.03	May	7 6 0	—	—
May	6 22 0	3128	18.73	July	7 0 55	3150	18.66	June	7 3 17	3115	18.18	June	7 8 0	—	—
June	6 10 18	3125	19.14	August	7 1 30	3092	18 24	July	7 7 12	3136	17.9	July	7 10 0	—	—
July	6 19 8	3107	19.05	September	6 21 8	3077	18.64	"	7 4 20	3097	17.89	August	7 3 0	—	—
August	6 18 19	3059	18.84	October	6 17 20	3061	18.98	August	7 1 35	3053	18	September	7 4 0	—	—
September	6 18 37	3063	18.84	"	7 1 40	3060	18.08	September	6 22 32	3049	18.31	October	7 3 0	—	—
October	6 15 0	3045	19.15	November	6 17 3	3046	18.92	October	7 2 36	3019	17.87	November	7 23 0	—	—
November	6 16 46	3041	18 92					November	7 11 51	3051	17	December	7 11 0	—	—
Average	6 18 51	—	18.90	Average	6 22 31	—	18.56	Average	7 3 58	—	17.89	Average	7 8 30	—	17.45
Mean speed of all passages, 18.68 knots.				Mean speed of all passages, 18.41 knots.				Mean speed of all passages, 17.52 knots.				Mean speed of all passages, 17.29 knots.			

THE RICHMOND BRIDGE.

The Richmond, Fredericksburg and Potomac Railroad bridge over the James River, at Richmond, Va., was built in 1890 by the Edge Moor Bridge Works for the Richmond, Fredericksburg and Potomac Railroad, under the personal supervision of Major E. T. D. Myers, general superintendent, and now president of the road. It is about 2,300 feet long, and consists of eleven pin connected deck spans of 176 feet each over the river, and 180 feet of viaduct of 30 and 60 feet girder spans at each end. The floor is about 90 feet above the bed of the stream. The river spans rest on iron towers about 46 feet high above the masonry piers. The trusses were designed for a load of two 100 ton engines, followed by 4,000 pounds per foot. The iron floor was calculated for an engine weighing 150,000 pounds on a wheel base of 18 feet. All the bracing of the towers and the lateral bracing of spans was made of angle iron to resist compression as well as tension, and no adjustable members were allowed in the trusses. All of the riveted members are of wrought iron, the eye bars and pins of low steel. The weight of iron in the whole structure was 3,700,000 pounds.

OHIO CONNECTING RAILWAY BRIDGE.

A notable engineering feat was performed during the past summer in floating into place the main span of the Ohio Connecting Railway Bridge at Brunot's Island, of which Mr. M. J. Becker, Past President of the Society, is the chief engineer. Bridge spans have been floated into place before, notably those for the Conway tubular bridge of 400 feet span, the Britannia tubular bridge of 470 feet span, and more recently for the new Tay bridge with spans of 245 feet, and for the Hawkesbury bridge in Australia, with spans of 416 feet; but the span over the Ohio River is longer than any of those, and is the longest span thus far handled in this way.

The span is discontinuous, single track, 523 feet long between centers of end pins, 25 feet wide and 65 feet deep; its top chord is 143 feet above pool water level and the ironwork weighs about 915 tons. It was originally intended to erect it in the ordinary way, upon false works resting on piles and built across the channel. Although this method of erection would comply with the requirements of the law, provided one other span was left open while the main span remained closed, some damage would result to the navigation interests, as the other spans could be used by boats only at uncertain and rare times. The change in the method of erection was dictated by the desire of the Ohio Connecting Railway Company to cause the least possible interference with the navigation of the river. The changed plan, as adopted, involved no change whatever in the iron work of the superstructure.

The span was first erected upon false works very similar to the ordinary kind, but placed in shallow water along shore, and the piles arranged so that coal boats could be inserted at right angles in every other panel but one. The coal boats were of the standard pattern in use on the Ohio River. They were purchased new and sold after the work was concluded at but a small sacrifice. Nine boats were used, each 26×130 feet in size. These boats were inserted after they had been partly filled with water, and after insertion the water was pumped out, and the span, including false works, was thus lifted clear of the supporting piles. The floating structure was then moved out, by means of lines connected to both shores, and towed into position between the piers, when the span was lowered by allowing the water to enter the boats through holes which had been bored in the bottoms for the purpose. The operation, which took place August 19, 1890, lasted one full day, but the boats and false works were not removed until the morning of the following day.

The span of 416 feet in the same bridge over the back channel on the other side of the island was erected by using the same false works after shortening them. They were floated around the island into the back channel, and there lowered upon piles which had previously been driven across the channel. Both operations were successfully performed without accident. This method of erection was devised and the work superintended by C. L. Strobel, M. Am. Soc. C. E. It illustrates what can be done in cases where a cantilever is too expensive or is otherwise objectionable; as the method avoids the putting up of stationary false works across the main channel of a stream, and its attendant risks and interference with navigation.

NEWPORT AND CINCINNATI BRIDGE.

The Newport and Cincinnati Bridge, now in process of construction by the King Iron Bridge and Manufacturing Company, is designed for ordinary highway and street car travel, and has a total length of 2,900 feet. The length of bridge proper, between abutments, is 2,347 feet, made up as follows: One main channel span 520 feet, made up of two 156 feet cantilever arms and a suspended span of 208 feet, two side cantilever spans 252 feet each, two truss spans 254 feet each, one truss span 162 feet, one of 108 feet, and seventeen viaduct spans from 26 to 54 feet each. The bridge has a clear width between trusses of 24 feet and two walks each 7 feet clear, and is provided with a double plank floor supported by iron longitudinal stringers. The stringers, floor beams and connections for the same are designed for a moving load of 100 pounds per square foot of clear roadway and walks, or a 15 ton Aveling & Porter steam road roller. The 108 feet span is proportioned for a moving load of 100 pounds per square foot; the 162 feet span for 85 pounds; the suspended span and cantilever arms for 80 pounds, and the 254 feet spans for a load of 75 pounds per square foot of the clear space of roadway and walks. The trusses of the 162 feet and 254 feet and cantilever spans are made of steel; the shorter spans and the floor system of the entire bridge of iron.

The arrangement of spans and the skeleton design of the structure are practically as proposed by Mr. G. Bouscaren, M. Am. Soc. C. E. The calculating, detail designing and shop work have all been done by the King Bridge Company, under the direction of their engineers, Messrs. A. H. Porter and F. C. Osborn, members of the Society. Messrs. Ferris, Kaufman & Co., of Pittsburg, Pa., are the engineers for the company, and the work has been done under their specifications and instructions.

THE WINONA BRIDGE.

During the past year a single track railroad bridge has been built over the Mississippi River at Winona, Minnesota. It consists of two fixed spans of 240 feet; one of 360 feet, and of a draw span of 440 feet; the total length, exclusive of trestle approaches, being 1,290 feet.

The work has been done by the Union Bridge Company, and Mr. G. S. Morison, M. Am. Soc. C. E., is the chief engineer. The same bridge company also built a single track low grade bridge over the Arkansas River, at Fort Smith, Arkansas, for the Kansas and Arkansas Railroad Company. It consists of ten spans of 200 feet each, and one draw span of 370 feet, or a total length of 2,370 feet.

The piers, instead of being masonry, are composed of English Portland cement concrete, laid up in mould boards, and faced with Portland cement mortar after the removal of the mould boards. They were sunk by the pneumatic process on timber caissons to the rock (which has a maximum depth of 21 feet below low water in the river, and is overlaid with shifting sand) except in the case of two piers, where the shallow depth of water precluded the use of the pneumatic method, and where cofferdams were resorted to. The bridge was sufficiently finished on the first of April to allow trains to pass if it had been necessary.

THE TOWER BRIDGE, LONDON.

The Tower Bridge across the Thames at London, now approaching completion, was referred to by President Shinn, in his address last year, but the novelty of the design may warrant further description. The intent is to enable foot passengers to cross at all times, and to limit interruptions to wagon traffic to a minimum, the bridge being farther down the river than any of the existing bridges, and a portion of the river traffic requiring more headroom than the 29 ft. 6 in. which is afforded by the fixed spans at high water. For this purpose the main floor of the bridge is placed some 40 feet above the water, but the central span has also a second girder and floor giving 140 feet clear headroom at high water.

The total length, including approaches, is 2,640 feet, of which 880 feet is across the river proper. This is divided into three spans, the two side spans being of the braced suspension type, 270 feet clear, and the central span being 200 feet clear. The latter is composed of two leaves, weighing nearly 1,000 tons each, which fold up vertically on their hinges, and thus leave a passage for masted vessels 140 feet in the clear. The width of roadway is 60 feet on the side spans and 50 feet on the central span.

When the folding leaves of the lower floor are thus raised, all vehicular traffic must be suspended, but foot passengers are then to be hoisted to the upper floor on passenger elevators, and let down similarly on the side.

HIGH BRIDGES AND ENGINEERING STRUCTURES.

There was opened last October in the southern part of Chili, a viaduct for the Chilian State Railway, which is, perhaps, the highest in the world. It is 333 feet above the level of the Mallen River, from which it takes its name, and is 1,419 feet long, divided into five spans each 232 feet in length, and some approach spans. The total weight is 1,550 tons, and the designs were prepared by Mr. V. Amelio Lastana, a Chilian engineer.

Among high bridges, mention may also be made of the St. Giustena highway bridge in the Tyrol, which consists of an iron arch of a clear span of only 197 feet, at a clear height of 453 feet above the bottom of the ravine which it crosses. Naturally no false works were used, but it was built out from the two abutments simultaneously by traveling cranes, a cable, carrying a cage, being stretched across the ravine, and aiding materially in the work, which was completed in 1888.

The remark is sometimes heard that engineering works, and particularly bridges and viaducts, are great eyesores to the artistic public, and that engineers are rectangular utilitarians who pay no attention to looks. Indeed, it is said that part of the opposition to the extension of elevated railroads in some of our cities is because they (the elevated railways) are very ugly. How far an engineer will be justified in spending other people's money in ornament will depend upon the circumstances of the case, but as wealth and taste have increased, there seems to be a disposition on the part of capital to take a more liberal view of this matter than heretofore.

Engineers, therefore, in designing new structures, may profitably inquire how they will look from an æsthetic point of view, and in many cases artistic effect will follow, simply by arranging the outlines in accordance with the lines of maximum strains. Among recent works this may be illustrated by reference to the Merchants' bridge at St. Louis, the Thames River draw, and the Eiffel tower, in all of which cases the lines of the structures were designed by following closely the lines of the greatest strains.

European engineers have always given greater thought than we to the finished appearance of their works, particularly in cities, and this is well illustrated in the new Highway bridge at Hamburg, Germany, built by Mr. C. O. Gleim, our corresponding member, which is entered through one of the most beautiful portals thus far built.*

HIGH BUILDINGS IN CHICAGO.

It may be interesting to engineers to note a new departure in buildings. The use of passenger elevators having rendered the upper stories of houses as accessible and pleasant as those lower down, and the profitable results of investments in high buildings having brought in a greater rental from real estate than was hitherto believed possible, an evolution is now in progress in buildings in this country, somewhat similar to that which has taken place in American bridges, and to a certain extent the same engineers are being called upon to design the iron work and framing. Being best acquainted with what has recently been done in this direction in Chicago, I may be permitted to draw my illustrations from that city. It now possesses some eight or ten office buildings from ten to fourteen stories high, and some six or eight more are now well under way. One of these, the Women's Temperance Union Temple, is to be thirteen stories high, and another, the Masonic Temple, is to be twenty stories high, being 113 x 170 feet on the ground and 274 feet high above the sidewalk.

The salient feature in the mode of construction which has rendered these high buildings possible is that the principal portion of the weight, that of the floors and the roofs, instead of being carried upon the outer walls, is now supported by an internal skeleton of steel columns, placed tier upon tier in the building, and rigidly connected with the girders and floor beams which carry the cellular arch bricks which span and form the floors. The outer walls become a mere skin to keep out the weather, and in the more recent instances even this outer shell rests upon the girders which span the space between the columns; each story is thus practically independent of the others, save through connections at the posts. In the case of the Masonic Temple the outer piers are introduced simply for architectural effect, and inside of them are steel columns which carry all floor and spandrel loads. This building has two lines of vertical bracing, running from top to bottom through the narrow way of the structure.

This skeleton system of construction, in which the outer walls need be no more than 8 inches thick, not only allows of high buildings, but it economizes space and land, generally expensive, and it admits of leaving the front almost all windows, thus giving to the apartments of the building a luxury of light hitherto quite unknown. The construction must, of course, be entirely fireproof, and this, it is now believed, has been secured by improved methods.

A NEW BUILDING CRANE.

This method of steel construction has naturally led to the application of the modern erecting methods, which have proved so rapid, effective and economical in the putting up of bridges, and it thus substitutes steam power for the armies of men formerly employed about the construction of the walls. Thus in the erection of the new hotel, the Chicago, 100 feet by 165 feet on the ground, fourteen stories high and 170 feet above the sidewalk, all the steel columns, girders and floor beams were hoisted and put in place by a self-propelling rotary crane, which also hoisted itself from story to story. It ran over a movable track so as to reach every portion of the structure, and was worked by one man, who performed all the manipulations and did the firing. As soon as one story is erected an inclined track is laid, and the crane hauls itself up to the next story. When the top is reached the machine is taken to pieces and lowered down, after having handled, in this particular case, 1,700 tons of steel with a crew of 20 men, at the maximum rate of two stories per week, including the columns and beams complete. At one time the frame work was carried up six stories above all other construction. The building has vertical bracing from top to bottom, forming a tower about 60 x 80 feet in the center of the long side of an inner court. The steel work was furnished and erected by the Keystone Bridge Company.

FOUNDATIONS OF GREAT BUILDINGS.

It may be interesting in this connection to give an account of the way in which the foundations under these great buildings are prepared. The subsoil of Chicago consists of blue and gray clay, which grows softer at some distance below the surface. It yields to concentrated weight, and it is not safe to load it with more than 1½ to 2 tons to the square foot.

Formerly heavy buildings were founded upon wooden piles, but moisture being excluded by the clay, the piles rotted and allowed the buildings to settle. The present practice is to use large footing stones for moderate structures, but for great concentrated weights a bed is formed, of rails inclosed in concrete, under the piers which carry the iron and steel columns, so as to float the weight over the clay with a pressure of 1½ tons to the square foot, increased on rare occasions to 2 tons; and on top of this foundation a course of iron or steel I-beams is placed to carry the masonry of the pier on which the steel columns are to rest.

ELECTRICAL ENGINEERING.

The most rapid and remarkable engineering advance during the past year has been in various applications of electricity. It has been set to performing all sorts of duties, in addition to its former uses in the telegraph, the telephone, and the electric light. Now it is not only supplying motive power about our cities to run sewing machines, printing presses, ventilating fans, various grinding mills, elevators and church organs, and turning draw-bridges, but it is also being applied in machine shops to run cranes, hoists, shafting and machinery; also in mines to undercut and haul out coal, and to pump water. Also to propel launches and to handle guns and ammunition; and it has recently been applied to heating, cooking, soldering and welding, so that it seems difficult to foresee the future limits to its various applications.

WONDERFUL GROWTH OF ELECTRIC RAILWAYS.

The largest growth of this development, however, has been in street car propulsion. Ten years ago there were in the United States 3,500 miles of street railways, all operated by horses and mules; now the street car mileage of the country is as follows:

5,713	miles of track, operated by	animal power.
527	" " " "	cables.
554	" " " "	steam motors.
2,931	" " " "	electric motors.
9,725		

As the first commercially successful electric street railways date back only to the beginning of 1888, the 2,931 miles now operated have practically been built or equipped in three years, and the aggregate is still growing very fast; no less than 781 miles having been opened during the four months preceding the 1st of February of this year, to which date the above figures were made up. This 2,931 miles of electric railroad is operated by 4,407 motive cars, drawing some 6,000 trailers. Almost the whole of it is equipped upon the overhead trolley system, and not only are grades of 10 to 14 per cent. surmounted, but the roads are operated at speeds of 7 to 10 miles per hour, at a cost

* The various bridges and structures above mentioned were illustrated by stereopticon views.

materially less than that of animal power. The maximum speed may be stated at 20 miles per hour, and the maximum of a single electric car motor at 75 horse power, so that for speed, for power to ascend steep grades and for economy of operation the electric railroad is far superior to that operated by animals.

It has been suggested that these great strides of electricity as a motive power point to an eventual superseding of the locomotive in the operation of the ordinary railroads of the country, and that the economy resulting from the generation of the power with stationary engines, together with the saving of dead weight effected by substituting electric motors for steam locomotives, will more than warrant the expense of changing the present installations.

I doubt whether this is likely to be the result so long as the electric power is obtained from a wire overhead, chiefly because this method involves the abandonment of having each locomotive an independent, self-contained motor, which can be tossed aside in case of accident in the generation of power, without stopping the operation of the whole road, as would be the case were either the stationary engine, producing power, or the distributing wire to give out in an electric system; these parts of the plant being easy to watch and to repair in and about a city, but difficult to care for in the open country.

PROSPECTS OF THE STORAGE BATTERY SYSTEM.

The advantages of having self-contained electrical motors may, perhaps, be secured by improvements in storage batteries, and experiments are therefore eagerly being made by many inventors to reduce their present prohibitory weight. The most successful seems to be that of the Waddell-Entz storage battery car, which was tested on the 4th of May in Philadelphia, and which is reported to have worked quite satisfactorily. By using copper and iron plates instead of lead, and an alkaline instead of an acid solution, the weight is said to have been reduced to about one-half that of former storage batteries. Be this as it may, it seems now not unlikely that very much greater speed will be attained with electric motors than any which have yet been practically secured. There are many proposals for this purpose, and it is understood that an experimental line on the "Weenes Electric System" has already attained a speed of 115 miles per hour, at which speed the trains generally left the very imperfect track experimented upon, and that with a better plant it is confidently expected that this, as well as some other electric systems, will be able to operate at speeds of 150 miles per hour. At this great velocity the atmospheric resistance becomes a very important element, and experiments will become necessary to ascertain the best form to be given to the trains. I may say in this connection that I made some investigations on this subject some years ago, and became satisfied that even with our present trains a considerable portion of the resistance from air, and of the consumption of fuel, might be saved upon our fast trains, by a few modifications of our present railroad rolling stock.

ELECTRIC LIGHTING AND TELEPHONY.

Some additional statistics may assist in giving an impression of the growth of electrical engineering. The total number of incandescent lights in the United States, operated from central station plants, is stated at 1,740,000 and the total arc lights at 154,000. The horse power of engines employed in this connection is 400,000, in 1,379 plants, and the capital invested is $126,758,500. In addition to the above, there are said to be 900,000 incandescent lamps and 25,492 arc lamps operated from isolated plants.

The whole number of telephone companies' licensees of the American Bell Telephone Co. is 51, and the number of special licenses is 9. The combined capital is stated to be $85,000,000. The telephones in the hands of licensees and under rental number 411,511 and the number of subscribers is stated at 171,454. This includes both the American Bell Telephone Co. and the American Telephone and Telegraph (long distance) Co.; the longest distance over which conversation by telephone is now daily maintained being 750 miles—from Portland, Me., to Buffalo, N. Y.

THE SOCIETY'S AFFAIRS.

You will be pleased to know that there is sustained interest in the society, as evidenced both by new applications for membership and by attendance at the meetings. I may say, however, that the supply of papers for the *Transactions* has not been as liberal during the past year as would have been desirable, and that too many of them are postponed until the last moment, at convention time. As the *Transactions* constitute for many members the only intercourse which they have with the society, it is desirable that material, in the way of engineering papers, shall be both abundant and regular.

Recent growth and improvements in the technical press, in which a number of able editors have been giving accounts of engineering works as fast as they have been executed, has probably interfered with the preparation of papers. Engineers have found it easier to furnish notes to those editors than to prepare a complete paper for the society. The search made for information, however, through the technical press in the preparation of this address, has shown how imperfect and scanty such hurried accounts of current works must necessarily be; how much more valuable to the engineering student is a paper carefully prepared for our *Transactions*, and how much more the latter are likely to add to the reputation of an engineer. It is therefore hoped that the engineers who are carrying on important works and experiments shall prepare detailed papers for the society. The current accounts which appear in the technical press will merely whet the appetite for a full and accurate statement of the difficulties encountered, the means taken to overcome them, and the results finally achieved.

Especially is it desirable that such papers shall be discussed fully by the members, such discussions being not infrequently even more valuable than the papers themselves, by bringing out statements of the best engineering practice upon a particular subject. In order to promote this, the secretary will send out advance copies of papers which are to be discussed to members who are likely to have something to say about them, either verbally or in writing, and each member is requested to advise the secretary of the class of subjects in which he is most interested.

It is expected that the Columbian Exposition of 1893 shall afford to American engineers an opportunity to repay in part the heavy obligations contracted to foreign engineers in 1889. The members of this society who, with members of the Mining and Mechanical Engineers' Societies, visited Europe in that year were received with unexpected magnificence. They were treated not as cousins but as brothers, and their visit was one long series of delicate attentions and entertainments, not only from engineers, but from all classes of the community.

This began with the very landing in England, where the Americans were everywhere received and entertained by the engineers and the municipal authorities, and showered with private invitations and receptions. Not only did a large number of the prominent members of the British Institution of Civil Engineers give up their business and time to the showing to their visitors the principal engineering works, either completed or in progress, but on that occasion the important engineering and manufacturing establishments, usually hermetically closed to visitors, were thrown wide open to the Americans, the managers attending upon them to afford every desired information.

In London, by the express sanction of the lord mayor, aldermen and court of common council, we were given a dinner in Guildhall; the second time, it is said, in more than one hundred years that this noble hall has been used for any entertainment not given by the guilds themselves; and in addition to the examination of some twenty-nine engineering works and establishments, the programme included invitations to visit some seventeen objects of interest, as tourists rather than as engineers. These visits were paid, not in the usual way with ordinary sightseers, but under the happiest auspices. Thus Westminster Abbey was seen under the favor of the Dean, who gave us an address in King Henry VIIIth's Chapel, upon the historical associations of the Abbey. We were, when visiting the Lambeth Episcopal Palace, there received by the Archbishop of Canterbury, who gave us a most interesting talk upon the events which had occurred therein.

In visiting the palaces of the crown, the American engineers, instead of being limited to those portions usually open to the public, were by special permission of the Queen shown the private apartments; and I happen to know that upon the visit to Windsor Castle, the Queen had changed her own plans in order that the engineers might be admitted upon the day most convenient to them.

These attentions, together with a large number of private invitations and meetings with distinguished persons, impressed us greatly as to how good a thing it is in Europe, at least, to be an engineer.

In France, the same kind of attention and cordiality was shown to the American engineers, who were received upon landing by a delegation of the leading French engineers, taken to Paris on a special train, and that very night invited to an open air fete and illumination given in one of the parks by the municipality. Later on, during a series of some thirty-five visits to engineering works and points of interest, we were received and entertained by a delegation of the municipal council, and also by the President of the republic, who, being himself an engineer, told us that he received us as comrades, rather than as visitors, gave our officers the loan of his box at the opera, and invited them to a garden party at his palace. Indeed, the entertainments and invitations to the engineers, while in Paris, were so numerous that but a portion of them could be accepted, and we were at times heartily ashamed of the small numbers who were able to attend on most interesting occasions.

In Germany, again, the small number of the party who were able to spare the time to accept the invitation of the German engineers to visit them were most magnificently received, and were there again made aware how high our profession stands in Europe in the ranks of the general community. We hope, however, to reciprocate in part. An organization was formed last week in Chicago, particulars of which will be laid before you, to provide headquarters for the engineers who may visit the Columbian Exposition of 1893, and to invite them to an engineering congress. This will need to be supplemented by us with some invitations to foreign engineers to visit this country on that occasion, and with arrangements to entertain them in various cities. It is hoped that provision will be made to enable them to see our engineering works to the best advantage, and to meet the leading men who will best represent the growing importance and consideration accorded to our profession.

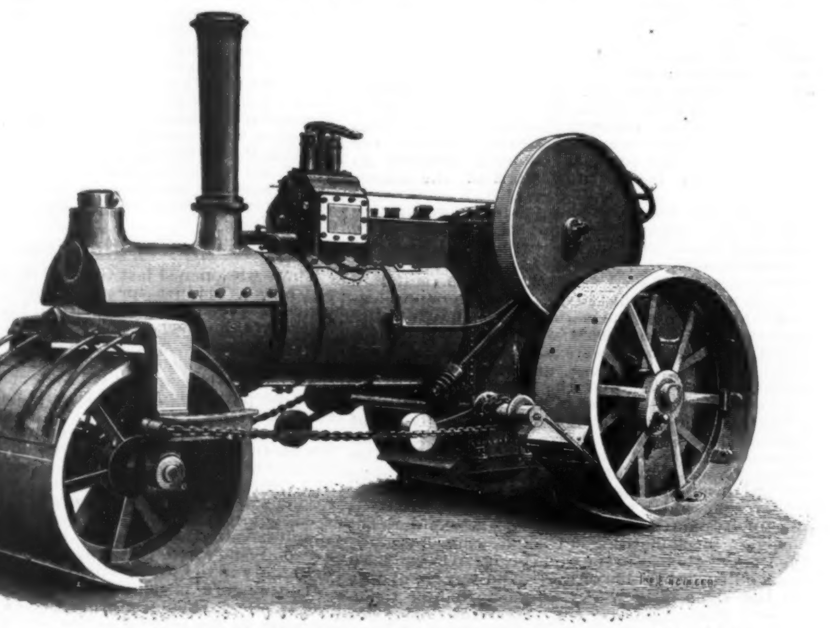
For we may as well acknowledge the fact that engineers in Europe hold a higher status among professional men than they do in this country. They are there looked upon as the leaders of the material development of the present age, and stand fully as high as men of any other profession. They are in chief charge of many industrial operations which are in this country managed by so-called practical men, and are consulted and employed before capital engages in any novel or important manufacturing enterprise.

It has not been always so. A century or so ago the English engineers seem to have occupied a far less desirable position than they do to-day. This is best illustrated by the compensation they then received. Thus the biographer of Telford says that his average income did not amount to more than is paid to the resident engineer of any modern railway, and that during the twenty-one years that he acted as principal engineer of the Caledonian Canal the amount paid to him was exactly $1,185 a year. Brindley is stated by the same authority to have been paid at the rate of 87 cents a day, while in chief charge of the surveys for the canal between Manchester and the Mersey, while now many English engineers are in the receipt of incomes fully as large as those of our railroad presidents.

This has been the result of the higher standards of requirements and business qualifications which have obtained in the profession, and of the increase in accumulated capital. As more important enterprises were undertaken, the disastrous results of intrusting them to half-trained men became more apparent, and the Jack-at-all-trades was replaced by the engineer.

A like evolution appears to be taking place in this country, not only through the more complete education and training which are being given in the technical colleges, and through the educational influence of societies of engineers like ours, but also through the great change in methods, which, during the past ten years, have led so many of our members to open offices for themselves, either as civil engineers to design and carry out works or as consulting engineers to place their experience and knowledge at the disposal of the public.

If, together with this better equipment for the pursuit of our chosen profession, the present high standard of professional honor and integrity be maintained, there are good grounds for believing there will result within the next few years a marked improvement in the independence, in the standing, and in the emoluments of the civil engineer.



IMPROVED ROAD ROLLER.

IMPROVED ROAD ROLLER.

AT the royal agricultural show this year a steam road roller was exhibited by Messrs. Wallis & Steevens, and is illustrated by our engraving from the *Engineer*. The roller is, of course, primarily for rolling, but it is equally suited for driving stone breakers and other machinery, or to be used—when supplied with road wheels—as a traction engine to haul the stones, etc., for the road repairs, or other work. By this means the roller can be kept in constant work. The design of the engine parts is similar to that of the same makers' traction engines. The cylinder is steam jacketed, being in direct communication with the boiler. The steam is carried over the cylinder to a domed chest before passing into the steam chest, to prevent any priming. The piston rod, crank, second motion shaft, and main axle are made of steel. The gearing is of the best cast crucible steel, and completely protected. The crank shaft bearings are carried on wrought iron saddle box, which is carried up from the boiler, thus obtaining rigidity. The boiler is made of steel plates, longitudinal seams double riveted, the riveting being done by machinery under a pressure of about fifty tons. The fire-box is of Lowmoor iron, and lap-welded tubes are used. The tender is of thick steel plates, and contains water tank and coal bunker. The boiler is lagged with wood and sheet iron. The wheels have wrought iron spokes and cast iron rims of hard tough iron. The hind wheels are provided with holes for insertion of frost spikes or short spikes for picking up roads, which can be put in when required. The roller is fitted with two speeds, the slow one for use when rolling and the fast one for use when traveling from

place to place or hauling. The roller can be turned in a space not much exceeding its own length. The regulator, reversing lever, steering wheel, etc., are arranged so that they all come readily to hand, and can be easily worked by one man.

ELECTRIC BOATS.

AT the naval exhibition, London, the Electric Power and Traction Co., in the grounds just outside the Camperdown gallery, has an electric pinnace, of which we give an illustration, Fig. 1, designed on the lines of the Admiralty steam pinnaces. It is 36 ft. long, 7 ft. beam, with a maximum draught of about 2 ft. It is built in pine with oak stem, stern, and stern posts, and is bright all over. The accumulators, 50 in number, are arranged in teak boxes under the seats, as shown in section, Fig. 2; and are so placed as to be easily removable when necessary. The whole is so strongly built that by suitable arrangements the pinnace can be slung on davits (see illustration, Fig. 3), with all electrical equipment ready for use. The cells can be charged either with the pinnace slung in the davits or moored alongside the ship. The motor is much more powerful than those usually supplied by the company for use in the launches on the Thames and at Windermere, and a speed of 11 miles per hour can be obtained for some three or four hours. Since these boats are principally used for shore purposes, speed and power have been considered of more importance than duration of run. For shore and harbor pinnaces electricity possesses many advantages over steam, and they no doubt will be largely in demand before long. These launches are ready for use at a moment's notice, and possessing none of the disadvantages of steam as regards dirt, smell and heat, commend themselves to the consideration of all. One of these pinnaces, 40 ft. long, 7 ft. 9 in. beam, and 2 ft. draught, with a handsome teak cabin, is now being built by the T. G. Electric Power and Traction Co. to the order of the naval department of the Russian government. It is expected that this launch will give fully 11 miles per hour. The company have demonstrated the sea-going properties of these pinnaces; they find them to have a very steady motion, even in a fairly high sea, and the center of gravity is so well placed that the rolling is little. The motors, having no reciprocating parts, run more smoothly than a high speed engine. This advantage will be specially felt when there is a tendency to racing of the propeller, and the whole of the electric details have been so carefully thought out and proved by actual experience that there is no fear of a hitch. Since the motor and accumulators are all arranged beneath the floor and seats, there is more room and greater comfort for passengers, and the carrying capacity of a given size boat is increased by about 50 per cent. The small torpedo boat running on the lake at the naval exhibition has been equipped with one of the company's launch motors, and the company have just received an order to build and equip a second boat of similar dimensions.—*Marine Engineer.*

Fig. 1.

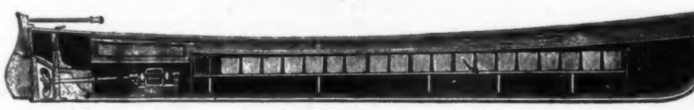


Fig. 2.

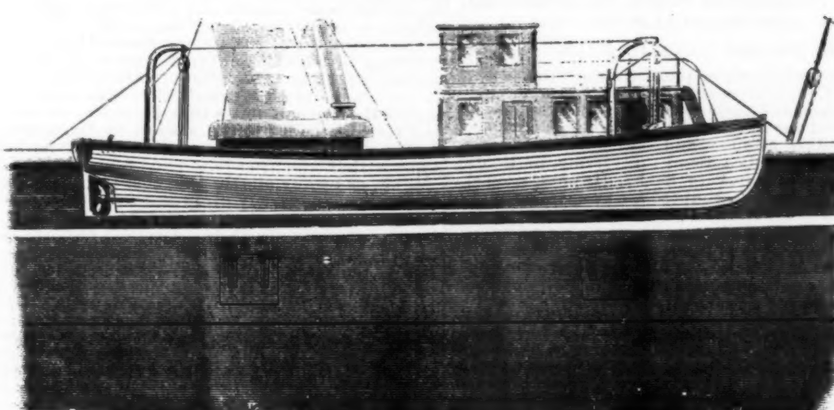


Fig. 3

ELECTRIC BOATS AT THE NAVAL EXHIBITION.

AMERICAN HARBOR ENGINEERING.

GEORGE Y. WISNER, C.E.

HARBOR improvement in the United States is to a great extent a monopoly in the hands of the Army Engineer Corps, but differs from monopolies in general in that its object is to absorb whatever credit there may be in any enterprise undertaken and to shift responsibility in case of failure.

Up to the present time the amount of money appropriated and expended for river and harbor improvements amounts to about $8,200,000 for surveys and examinations and $201,400,000 for construction and improvements. This amount, if judiciously expended in carrying out well devised plans, ought to have produced enough deep water ports for the commerce of the country and done much toward putting our interior waterways in a good navigable condition.

A comparison with the works of foreign countries makes an exceedingly unfavorable showing, while at the same time the engineering enterprises of this country conducted by civil engineers are both in design and execution unsurpassed in the world.

The reason for this failure in one case and success in the other is that the successful engineer is generally a specialist in his particular branch of engineering, while the government engineer seldom remains longer than three years on any one kind of work, and is debarred by military etiquette from doing any manual labor, and consequently specialists and practical men are the exception in the corps.

The lack of specialists in the army engineer corps is very evident from the plans that have been adopted by different engineer officers for the improvement of the harbors subject to bar formation from current action.

At Charleston, S. C., $144,700 was appropriated for the improvement of the harbor previous to 1878, which was expended in dredging and other tentative methods, without any beneficial results. The item was then dropped from the expenditure account and a new project formulated by the engineer officer in charge, estimated to cost when completed $1,800,000. This project was reviewed the same year by a board of engineer officers (two of whom have since been chiefs of the corps) who approved the plans and estimated the cost at $1,800,000 to $3,000,000, depending on the height it might be necessary to build the jetties.

Since 1878, $2,203,500 have been expended in carrying out this project, and in the last annual report of the Chief of Engineers it is estimated that $3,132,000 will be required to complete the improvement, or apparently the work is now $1,382,000 worse off than before anything was done. An examination of the latest charts of the harbor, however, hardly justifies this conclusion, as the present average depth of water on the bar is approximately the same as in 1878, or, in other words, the project is an utter failure.

The plan of improvement consists of two jetties of brush mattress foundation, about two feet thick, with riprap superstructure, one commencing on Sullivan's Island and the other on Morris Island, and converging toward each other for a distance of about 12,000 feet from shore and thence nearly parallel and about 2,800 feet apart, 4,000 feet to the outer crest of the bar. The rise and fall of water surface for an average tide is about five feet and for a spring tide about six feet.

The volume of water flowing across the bar for each tide was determined from a theoretical discussion of what the flow ought to be, and not from the observations made for that purpose. If the latter had been thoroughly studied, it is probable an entirely different plan would have been adopted.

Since jetties, however far completed from shore, must produce the same effect through that section of channel as when carried to any greater length, and as no material improvement of channel has occurred between those portions of the jetties which have been in place for several years, it is evident that to continue the present plans will produce no better results in the future.

At Sabine Pass, Texas, from 1852 to 1882, $170,000 were appropriated and expended in attempting to deepen the channel across the bar without effecting any permanent improvement. This amount was mostly expended on surveys and in dredging, but as the bar is composed of very soft mud, the dredged channels disappeared in a few months after the work was done.

In 1882 this item was dropped from the expense account of the harbor and a new project devised estimated to cost when completed $3,177,606.50. As this estimate of final cost was carried out to cents, it is inferred that much more certainty was felt in the final result than in that obtained from former experiment.

The project consists of two jetties, one 18,120 feet long and one 19,800 feet long, 4,000 feet apart at their junctions with the shore and gradually converging to a width of 2,000 feet at the outer ends on outer slope of the bar. There has now been expended on this project $125,000, with results that indicate beyond a question of doubt that the depth of channel expected will never be obtained under the present plans.

The jetties, as far as constructed, are composed of brush mattress work ballasted with riprap stone, the earlier work being about one ton of riprap for seven cubic yards of brush, and that put in more recently in building jetties to water surface, about one ton of rock for each one and one-half cubic yards of brush.

During the past eight years portions of this work have been built above ordinary gulf level on three different occasions, but have settled and worn away until very little of the jetties are to be seen now at average low tide.

A contract was recently let for expending $300,000 more on this work, all of which will be utilized in raising the jetties above average gulf level by placing rock of one to five tons weight on the crests of the present jetties.

The bar is composed of very fine, soft mud, into which an ordinary sounding pole may be pushed by hand to the depth of ten to fifteen feet. So it may easily be surmised what the result will be to place 70,000 tons of rock on a structure already settling into the gulf bottom under its present weight.

It is a fixed principle in harbor improvement by means of jetties that the works as far as completed must produce the same results between jetties as may be expected when carried to any distance farther seaward, or in other words, the channel formed as the work progresses forms a basis on which to predict final results.

The jetties now in place at Sabine Pass have been constructed sufficiently long that the channel between them has formed for itself a normal section corresponding to the volume of discharge through the pass. Where the original depths were less than ten feet scour has occurred, but where greater than twelve feet no increase of depth has been obtained, showing that with the width between jetties adopted, twelve feet is the maximum depth of channel that can be expected from natural forces.

Sabine Pass is from one-half mile to one and one-third miles wide and varies in depth from 18 to 36 feet.

The channel of 18 feet and more in depth only averages about 500 feet wide, and as the flow through the shallow portions of the sections is greatly retarded by bottom friction, the effective section cannot be considered over 1,000 feet wide.

During a considerable portion of each year the volume of discharge through the pass is made up of the water from the Sabine and Naches Rivers and that due to tidal action. When the former is sufficient to fill the tidal reservoir as rapidly as the tide rises in the gulf, the flow is entirely of river water, but when not, there is often a current of salt water running up stream at the same time that the lighter fresh water escapes seaward as a surface current.

With jetties wider apart than width of effective cross section of the pass, this will be the case much of the time, and consequently very little scour will occur, even when the surface velocities indicate a heavy current.

If the width between jetties had been planned to accommodate flood volume of the Sabine and Naches Rivers, the problem would have been somewhat similar to that of the South Pass entrance of the Mississippi River, and a channel of at least 20 feet depth would have been secured.

No determinations of current velocities and volume of discharge were ever made on which to base plans. Without these data the matter of determining width for jetty channel was necessarily a guess, and in this case has proved to be a very expensive one.

At Galveston, Texas, the folly of the so-called "tentative" methods of engineering of the Engineer Corps has been fully demonstrated.

The pass between Galveston Island and Boliver Point forming the entrance to the harbor has a surface width of about 9,000 feet, with an effective width of about 4,000 feet and the distance of outer edge of the bar from shore about five miles. To make a deep water channel across this bar submerged parallel jetties 12,000 feet apart (four times the width of the effective cross section of the Pass) were recommended, with the expectation that the currents developed by tides having a mean rise and fall of only one and one-tenth feet would have sufficient force to scour the sand from the bar and transport it into the deeper waters of the gulf.

From 1870 to 1880, $618,432 were expended on this

project and it was then abandoned, the works having disappeared in the sands of the gulf without producing any beneficial results.

The jetties at the mouth of the Mississippi River, under the direction of competent civil engineers, having in the meantime proved a great success, it was decided to adopt the same system of construction for the work at Galveston.

From 1880 to 1883, $959,568 were expended on this new project, without securing any improvement in the depths on the bar.

The citizens of Galveston becoming dissatisfied with the expenditure of such vast sums without results, requested the late Capt. James B. Eads to submit a proposition to enter into a contract to secure a 30 foot channel on the plan of "Deep water or no pay." Capt. Eads, after a careful examination, offered to enter into a contract to obtain a permanent 30 foot channel across the bar for the sum of $7,750,000.

The government engineers, however, maintained that with $750,000 they could complete this project and give a 25 foot channel across the bar inside of two years, and on this representation succeeded in defeating the bill in Congress. No further appropriations were made for this work until 1886, and in the mean time the teredo had eaten the brush of the mattress work to such an extent that not ten per cent. of the original work remained.

The fact that the physical characteristics of the Mississippi River with its heavy annual discharge of sediment were entirely different from those of Galveston harbor now dawned on the minds of the engineer officers, and a new plan was devised.

The new project contemplated building two jetties 7,000 feet apart (nearly twice the effective cross section of the Pass), to be constructed of ordinary riprap stone to the water surface and then capped with heavy block rock of one to ten tons weight, and estimated to cost when completed $7,000,000. Since then $800,000 have been expended in carrying out these plans, and a contract was recently let, under which, if ever completed, the balance of the work required will cost $7,000,000 more. To this, if we add $400,000 required for office and engineering expenses during the progress of the work, we have the grand total of $8,200,000 for accomplishing what a private individual agreed to do for $7,750,000 and guarantee results.

The defects in the present plans are incorrect location of the jetties, excessive width of cross section, and the fact that in ten lineal miles of loose riprap jetty work the loss of water from leakage will be so great that there will be no scouring force at the outer end of the work.

With jetties 7,000 feet apart, 30,000,000 cubic yards of material will have to be removed from the bar to produce the channel expected, which, distributed in front of the jetty entrance, would produce a shoaling of three feet over an area of ten square miles, and as the slope of the gulf bottom beyond the bar is only one foot in three thousand, the probable result is evident.

At the mouth of the Mississippi River the Engineer Corps expended $2,614,000, without securing any beneficial results whatever. The work was then placed in the hands of competent civil engineers, who in less than four years' time opened a permanent channel 33 feet deep at a cost to the government of $5,250,000 and a net profit to themselves of over $2,000,000.

This project met the united opposition of the entire corps, and it was no fault of theirs that they did not succeed in rendering it a failure. These jetties have now been completed twelve years and have sustained no damage from storm, except to the concrete coping wall of the east jetty, which was not properly designed to resist the shock of heavy seas. The writer rebuilt this sea wall in 1889, and in the report of the chief of engineers for the same year will be found plates illustrating the plant and devices used in the work, but in the explanatory notes no statement that would lead the casual reader to infer that the devices had an origin outside of the corps.

At the mouth of the Brazos River, Texas, the corps, after having used appropriations amounting to $158,000, abandoned the enterprise as impracticable, with not a single yard of jetty left in sight to show for this vast expenditure.

The engineer officer in charge in making his final report in 1887 says the forces of the river are not capable of scouring a channel to exceed ten feet in depth, and that the attempt to maintain six feet would be a doubtful experiment.

The stream has a drainage area of over 40,000 square miles and at flood stage has a discharge of 60,000 cubic feet per second. There are, however, no records to show that the physical characteristics of the stream were known at the office when the above report was made.

In 1888 private parties obtained a charter from Congress, granting the privilege of opening a deep water harbor at the mouth of the Brazos, without expense to the government. Although the corps had officially abandoned this project as impracticable, they did everything possible to defeat the measures in Congress, but were not successful.

Work of construction was commenced in 1889 and a channel 26 to 30 feet deep has been obtained and maintained through all completed work, and across the bar there is to-day deeper water than at any point west of the Mississippi River.

Financial troubles have delayed the completion of the work over a year since the commencement, in 1889. So that the above results have been obtained in a little over a year of actual work. The project consists of two parallel jetties of 560 ft. clear width, constructed of brush mattress work ballasted with stone.

About one ton of stone was used for ballasting five cubic yards of brush. The brushwork is built so as to be, when compressed, at low water level, and when thoroughly constructed is to be capped with a concrete wall built in place, and weighing about two tons per lineal foot.

New methods of construction were devised by the writer, while engineer in charge of this work, by which the expense of construction was materially lessened and the rapidity with which the work could be done greatly increased. These methods have since been adopted and are now being used by the chief engineer of the jetty work at Tampico, Mexico, and also in a modified form by two officers in charge of the harbor work on the Pacific coast.

At Aransas Pass, Texas, $581,250 have been expended in an attempt to deepen the channel across the bar to a depth of 20 feet. No appreciable result has been obtained, except to narrow the surface width of the Pass 1,700 feet, thus making the problem a much more difficult one than before any work was done. The project, as tried, was to construct two parallel jetties of brush and stone (2,000 feet apart), from shore to the outer crest of the bar, and depend on tidal action to produce the necessary scour to cut channel across the bar. The effective width of the channel through the pass is only 500 feet, or about one third of that proposed between jetties.

The government has now abandoned the work and a private company have procured a charter and propose to open a deep water harbor there, at their own expense. Owing to financial difficulties, no work of construction has yet been started.

The harbor at Grand Marais, Michigan, on the south shore of Lake Superior, has all the natural characteristics, if properly utilized, to make one of the finest harbors on our lake coasts. The government has attempted to construct a harbor of refuge there, at an estimated cost $450,000, but which, under the plans adopted, will at best prove but a doubtful experiment.

The harbor consists of a natural indentation of the coast line, about one and one-half miles long, with a drift formation of sand and gravel extending about two-thirds its length between the harbor and lake. The plan adopted is to build two crib piers, 300 feet apart, at right angles to the gravel spit, out to 24 feet of water, and then dredge the channel between to required depth.

Up to the present time $203,600 has been expended on the project, but as yet no better channel has been secured than that at the natural entrance of the harbor. In 1882, a channel 12 feet deep was dredged between the piers and across the gravel spit to deep water in the harbor, but inside of one month after completion a single storm completely closed the opening. In 1889 the channel was dredged again to a depth of 17 feet between the piers, which during the following winter shoaled to 9 feet.

The river and harbor bill for 1890 contains an item appropriating $3,000 to remove obstacles at the mouth of Squan River, N. J. This paragraph of itself would attract no attention, but when we consider that the so called obstructions cost the government $39,000 and were caused by the construction works placed there under the direction of the engineer corps, comment is unnecessary.

If the improvement of harbors was open to competition, there is no question but that the civil engineers would accomplish the work for much less than it now costs, and that, too, on the principle of results or no pay.

It seems strange that this state of affairs should have existed as long as it has, but members of Congress are at last beginning to realize that a change must be made, and when that time comes, the graduates of our technical institutions should be prepared to conduct the works placed in their charge in a manner creditable to themselves and to the profession they represent.—*The Technic.*

THE PHOTOGRAPHIC WORK OF HERSCHEL AND FOX TALBOT.*

By WILLIAM LANG, Jr., F.C.S.

THE two scientists whose photographic work is dealt with in the following communication were virtually contemporaries, and their connection with the town in which we hold our present Photographic Convention may be described as direct and indirect. Talbot's connection was essentially a direct one, living, as he did, within a short distance of Bath. Herschel's, on the other hand, has to be accounted for in the fact that his father, Sir William Herschel, resided here for several years before his appointment as private astronomer to George III. necessitated his removal to Slough, in the neighborhood of Windsor. To the student, therefore, of the history of photography, Bath will have something more than a passing interest—for him it will be forever classic ground. I only wish that the summarizing of the work done by Herschel and Fox Talbot had been placed in worthier hands than mine, but, having been intrusted with the task, I shall do my best to acquit myself of it.

In the first number of the *Edinburgh Philosophical Journal*, which made its appearance in June, 1819, the second contribution we find to be from Herschel, and its title *On the Hyposulphurous Acid and its Compounds.* In the opening sentence we are told that the experiments about to be described are the result of an accident. Experimenting with sulphide of lime, and noticing a bitterness in the liquid when almost wholly decomposed similar to that of Epsom salts, and which could not be accounted for, Herschel was led to examine the properties of the body giving this characteristic bitterness, and which Herschel showed to be hyposulphite of lime. From the hyposulphite thus produced, other hyposulphites were prepared. In the memoir these salts—at all events the more important—have their properties described. The action of hyposulphite of soda and of the corresponding salt of potash on chloride of silver is distinctly set forth. Referring to the soda salt, we find it stated in the memoir, "Muriate of silver, newly precipitated, dissolves in this salt, when in a somewhat concentrated solution, in large quantity, and almost as readily as sugar in water." Herschel states it broadly that all liquid hyposulphites dissolve muriate, or, as we call it now, chloride of silver. He points out the fact that such a solution possesses great sweetness to the taste, and that most of the ordinary tests for silver fail to show the presence of that metal in the solution. He further shows that zinc can separate metallic silver on being immersed in the hyposulphite solution. In conclusion it may be noted that the contribution is dated Slough, January 8, 1819.

Herschel had evidently found congenial work in tracing out further reactions connected with the hyposulphites. In the same volume of the *Edinburgh Philosophical Journal* occurs another contribution—additional facts relative to the hyposulphurous acid. This appeared in the October issue, and the date affixed to the article is May 15, 1819. Time fails us to refer in detail to the various facts brought forward, but one observation deserves to be noted, viz., that where silver iodide is described as sparingly soluble in hyposulphites. It has to be remembered silver bromide was then unknown, bromine not being discovered till 1826; the salts of silver thus treated by Herschel were chloride, carbonate, phosphate, borate, malate, sulphite, and arseniate. The second volume of the same journal has one other memoir—some additional facts relating to the habitudes of the hyposulphurous acid and its union with metallic oxides. This contribution is dated Slough, November, 1819. The true importance of these researches did not make itself manifest till some twenty years later, when the necessity of removing the unacted-on silver salt from the developed image became apparent. Daguerre and Talbot's methods, as first propounded by their respective authors, were far from perfect, being images not sufficiently fixed. Herschel himself called the attention of these investigators to his early experiments, and the employment of hyposulphite of soda for the final operations made the Frenchman's and the Englishman's processes thoroughly complete.

As Herschel seems to have been the first to analyze colored flames by means of a prism, it may be as well here to note the fact, although it may not strictly be termed photographic. In 1822, in the Edinburgh Royal Society's *Transactions*, page 455, a memoir is contributed *On the Absorption of Light by Colored Media, and on the Colors of the Prismatic Spectrum, with an Account of a Ready Mode of Determining the Absolute Dispersive Power of Any Medium by Direct Experiment.*

In 1827, Herschel, among other articles, wrote that on light in the *Encyclopædia Metropolitana.* Up to about this time Herschel had been an adherent of the emission theory of light, but the labors of Young and Fresnel had induced him to accept the undulatory theory.

In 1832, a short communication in the form of a letter was made to the British Association at their second meeting, which was held at Oxford. The title of the paper indicates the subject matter—*On the Action of Light in Determining the Precipitation of Muriate of Platinum by Lime Water.*

Herschel went abroad in the latter end of 1833 to carry out a long cherished desire to survey the heavens of the southern hemisphere. His destination was Feldhausen, six miles from Capetown, and here for four years were carried on those astronomical observations which will for all time be associated with the name of Herschel. I am not aware that during the period in question anything bearing sufficiently intimately on what may be called photographic research has to be recorded, although solar radiation observations were made from time to time. The third meeting of the British Association was held at Cambridge in the month of June, 1833. Two papers were contributed by Herschel, *On the Absorption by Light of Colored Media, viewed in Connection with the Undulatory Theory*, and *The Principle and Construction of the Actinometer.* It has to be noted that the instrument described was one destined to estimate the heating power of the sun's rays, not what we photographers understand by the title. The former paper appears only in abstract in the Association Reports, but was printed *in extenso* in the *London and Edinburgh Philosophical Magazine and Journal*, vol. iii., p. 401.

Before the Royal Society, on March 14, 1839, a paper was read by Herschel, entitled *Note on the Art of Photography; or the Application of Chemical Rays of Light to the Purposes of Pictorial Representation.* At the outset the author states that his attention had been but recently called to the subject of Daguerre's concealed photographic processes, and that he had not known that the question had been considered by Talbot, or by any one in this country; as an enigma to be solved, a variety of processes at once presented themselves. First, the so-called deoxidizing power of the chemical rays in their action on recently precipitated silver chloride; secondly, the instant precipitation of a mixture of platinum chloride and lime water by light, forming an insoluble compound, which might be blackened by various reagents; and, fourthly, the decomposition of an argentine compound, soluble in water exposed to light in an atmosphere of peroxide of chlorine. Confining his attention to silver chloride, the author inquires into the methods whereby the blackened traces can be preserved and the unaltered salt removed. This state of things can best be brought about by the use of the liquid hyposulphites. The author then specifies other salts of silver more sensitive to light than the chloride, viz., the carbonate, acetate and nitrate. Commenting on investigations to be made on the spectrum, he advocates that the spectrum be produced, not by the prism, but according to Fraunhofer's method, by the interference of the rays of light themselves in passing through gratings, and fixed by the heliostat.

Accompanying the paper thus briefly referred to were twenty-three specimens of photographs, one a picture of the large telescope at Slough, produced in the camera. Through the kindness of Professor A. S. Herschel, I am enabled to show a photographic reproduction of the frame of the great telescope belonging, if not to this particular period of the year, at all events to several months later.

The year 1839, I need scarcely remind a photographic gathering, gave to the world Daguerre's method of securing "sun pictures," and, as has been but recently divulged before the annual meeting of the British Association, we find it engaging the attention of the mathematics and physics section. Talbot's remarks will be referred to when I come to deal with his work. Herschel's contribution on that occasion was a letter addressed to the president of the section, wherein he stated that, in experimenting with Talbot's paper and exposing it to the spectrum, he got colored impressions. He also records the action of the red rays on paper which had, in the first instance, been exposed to light. On February 20, 1840, Herschel presented to the Royal Society a paper entitled *On the Chemical Action of the Rays of the Solar Spectrum on the Preparations of Silver and Other Substances, both Metallic and Non-metallic.* The reading of the paper extended over three meetings, viz., 20th and 27th February and 5th March. The whole memoir is full of suggestive material; there is only time to note one or two of the more important points. The terms positive and negative are here introduced for the first time to indicate re-

* A paper read before the Photographic Convention of the United Kingdom, 1891.

spectively pictures in which the lights and shades are the same as in nature, and in which they are the opposite (par. 8), and these distinctive terms remain with us to this day. The first part of the memoir is devoted to the fixing of photographs, and the comparative merits of hyposulphites, potassium iodide, potassium ferrocyanide, etc., are discussed. The bleaching of the image by mercuric chloride is here recorded (par. 19). The second part relates to the taking of photographic copies and transfers. The third treats of the preparation of photographic paper, the photographic possibilities of lead compounds. The author describes a method of precipitating on glass sensitive silver compounds, and refers to such films being likely to lead to an extension of the art of photography. After stating results of his experiments with iodide, bromide and chloride of silver, he suggests that similar experiments be made with silver fluoride. Gold and silver salts were also experimented on.

The fourth division of the paper is occupied with what the author calls the chemical analysis of the solar spectrum. It would be beyond the limits of this communication to go further into all the experiments and speculations recorded in this classical memoir. The paper occupies sixty pages of the printed *Transactions* of the Royal Society, and it may be regarded as the foundation stone on which subsequent researches and experiments have been reared. One of the society's medals was awarded to the author for this contribution to science.

The eleventh meeting of the British Association was held at Plymouth in July, 1841. Herschel, on that occasion, addressed a letter to the Physical Section, accompanied by fifteen specimens of colored photographic copies of engravings and mezzotints, "the whole" (as the writer puts it) "being tinted with substances of vegetable origin, variously prepared."

In the following year, viz., 1842, another memoir was presented to the Royal Society, *On the Action of the Rays of the Solar Spectrum on Vegetable Colors, and on some New Photographic Processes*. Although appearing in the *Philosophical Transactions* as one contribution, there were originally three papers read before the Royal Society, the respective dates of which were June 16 and November 17 and 24. The memoir is a continuation of the one given in 1840. Elaborate experiments with gum guiacum and expressed juices of flowers are first given in detail, and these are followed by others where the salts of iron have their reactions studied, the outcome of which we have in the two photographic processes known as chrysotype and cyanotype. Briefly stated, the first-named consists in coating paper with a solution of ammonia-citrate of iron, exposing to light, and afterward developing with a solution of gold chloride. Some specimens thus prepared are here, by way of illustration. The fixing of chrysotype was effected by means of potassium iodide. The reduced iron compound can also be rendered apparent by means of a solution of silver nitrate. A print thus produced is here for inspection. Cyanotype is perhaps better known to most of us as the blue process. In this method, development is effected by means of a solution of potassium ferricyanide, red prussiate of potash. The memoir. closes with some experiments bearing on the photographic properties of mercury.

In these early years of the photographic art, the *Athenæum* was in the habit of reporting matters appertaining to photography. In consequence of some discrepancies in the account given by this paper of the foregoing discoveries, we find a letter from Herschel making the necessary corrections. The letter, dated 10th August, 1842, appears in No. 773, p. 748, of the *Athenæum*.

Professor Draper, of New York, having, toward the end of 1842, presented Herschel with a daguerreotype impression of the solar spectrum, the latter, in acknowledging its receipt, contributes to the *Philosophical Magazine* an article entitled "Action of the Rays of the Solar Spectrum on the Daguerreotype Plate." From it we learn that Herschel had himself been experimenting in securing spectrum impressions on daguerreotype plates, and, although he admits that his manipulation was not all that could be desired, still his results were such that comparisons could be instituted between Draper's plate and his own. The whole tenor of the paper is philosophical, and occupies twelve pages of vol. xxii. of the journal already referred to.

At the Cork meeting of the British Association in August, 1843, a paper was communicated by Herschel —*Notice of a Remarkable Photographic Process, by which Dormant Pictures are Produced Capable of Development by the Breath or by Keeping in a Moist Atmosphere*.

In the *Philosophical Transactions* for 1843 we find another memoir contributed to the Royal Society—*On Certain Improvements in Photographic Processes Described in a former Communication, and on the Parathermic Rays of the Solar Spectrum*. This communication was made on November 24, and is, in effect, a continuation of the two former memoirs, the numbering of the paragraphs running continuously throughout.

At the York meeting of the British Association, held in September, 1844, Herschel announced a new photographic process, to which he gave the name of amphitype, a term suggested by Talbot, in consequence of the picture, according to the method adopted in the subsequent manipulations, becoming either a positive or a negative reproduction. It may be here remarked that Herschel, in all these experiments, seems to have used engravings instead of the ordinary negative. Herschel, from his researches, had realized the fact that silver bromide was more sensitive to light, or, rather, that it was affected by a wider range of the rays forming the solar spectrum, than silver iodide, which formed the staple of calotype, and afterward that of the collodion process. Accordingly, when the Photographic Society of London was formed, in 1853, among the first contributions to its *Transactions* we find one from Heschel—*On the Substitution of Bromine for Iodine in Photographic Processes*. This paper was read June 2, and I may be allowed to quote one pregnant sentence from it, which may almost be regarded as prophetic: "A new photography has to be created, of which bromine is the basis." In 1855, Herschel advocated the desirability of securing daily photographic representations of the sun. The original communication was read before the Astronomical Society, and will be found in the volume for 1854-55 of the *Monthly Notices* of the Society. It is also to be found reported in the *Athenæum*, in No. 1435.

In 1858, at the Leeds meeting of the British Association, Herschel presided over Section B, the chemical, and his introductory remarks, so far as they relate to our own science of photography, may be appropriately quoted. The words used by Herschel in 1858 are no less significant in our own day:

"Hitherto the more attractive applications of photography have had too much the effect of distracting the attention from the purely chemical question which it raises, but the more we consider them in the abstract the more strongly they force themselves on our notice, and I look forward to their occupying a much larger space in the domain of chemical inquiry than is the case at present."

The same sentiment regarding photography has been otherwise expressed by Major Russell, who is credited with having said that photography would be a most interesting subject were it not for the pictures.

In 1859 an article from Herschel appeared in the second volume of the *Photographic News*, in the number for July 22, "The Action of the Solar Spectrum upon Certain Compounds of Silver," and in the third volume of the same paper, in the number for September 9, under the same title, a further communication is to be found. This article has an accompanying illustration of the apparatus employed by the author in securing his spectra impressions.

In the *Photographic News* of May 11, 1860 (vol. iv.), Herschel contributes an article, "Instantaneous Photography." He discusses the possibility of taking a rapid series of pictures of moving objects, and recombining them in the optical apparatus, the phenakistiscope. The appearance of motion is again imparted to the eye when the pictures are rapidly revolved. This method, as you are all aware, has been adopted by Muybridge. A term is used by Herschel in this communication which, although common enough nowadays, is very significant, and describes well the taking of an instantaneous picture. I refer to the term "snap shot." I make the statement subject, of course, to correction, but I think we may give to Herschel the credit of coining this photographic term for us equally with the better known terms of "positive" and "negative."

In 1861, in the eighth volume, page 384, of the *British Journal of Photography*, Herschel contributes an article, "Forms of Lenses suited for Destroying Spherical Aberration."

The foregoing represents an epitome of the work done by Herschel. We will now consider Talbot's share in the development of our art.

Talbot's experimental photographic work appears to have been begun about the year 1834. By means of paper impregnated with silver chloride, Talbot asserts that he had secured camera pictures of his residence as early as 1835 (*vide* appendix to second edition of Tissandier's *Photography*, written by Talbot). It was not, however, till January 25, 1839, at one of the Friday meetings of the Royal Institution, that the process was first publicly announced, and as Faraday, who brought the matter forward, explained, it was done so for the purpose of "establishing a date." Daguerre's process had been announced in January, but the particulars were only known to his friend Arago. Talbot had in the meantime sent in a paper to the Royal Society, and he was afraid that Daguerre's process might be divulged before his communication to the Royal Society was published. On the Thursday following, however, viz., January 31, 1839, Talbot's paper, entitled, *Some Account of the Art of Photographic Drawing; or, the Process by which Natural Objects may be made to Delineate Themselves without the Aid of the Artist's Pencil*, was read. The paper was not published in the *Philosophical Transactions*, but an abstract of it is given in the *Proceedings of the Royal Society*, vol. iv., p. 120. It was printed *in extenso* in the *London and Edinburgh Philosophical Magazine*, March, 1839, vol. xiv., p. 209. Both at the Royal Institution meeting and that of the Royal Society, specimens of "photogenic drawing" were exhibited, along with the camera pictures of Talbot's residence. On February 21, 1839, a paper entitled *An Account of the Processes Employed in Photogenic Drawing* was communicated to the Royal Society. The memoir divides itself into two parts, first the preparation of the paper, and secondly the fixing of the design, which was effected by a solution of potassium iodide of the proper strength, or by a strong solution of sodium chloride. Talbot at this stage was doing little more than producing negative designs from opaque natural objects.

A communication from Talbot to the *Philosophical Magazine*, "On a New Property of the Iodide of Silver," may be here referred to. It appears at p. 258, vol. xii., and is a note of the appearance that silver iodide presents when heat is applied. A pale primrose yellow when cold, this salt when exposed to the heat of a fire turns to a rich, gaudy yellow. Before passing on to consider Talbot's later researches, I may be allowed to refer, as briefly as possible, to some of his earlier work, giving the original source of publication.

In 1826, "Some Experiments on Colored Flame," *Edinburgh Journal of Science*, v.

In 1827, "On Monochromatic Light," *Quarterly Journal of Science*, vol. xxii.

In 1833, "Remarks on Chemical Changes of Color," *Philosophical Magazine*, vol. ii.

In 1834, "Experiments on Light," *Philosophical Magazine*, vol. v., pp. 321-334; and *Royal Society Proceedings*, p. 298, vol. iii.

In 1835, "On Nature of Light," *Philosophical Magazine*, vol. vii.

The foregoing by no means exhaust the scientific contributions of Talbot. His mathematical memoirs were considerable. A Royal Society's medal was awarded him in 1838 for "Researches in Integral Calculus."

Dealing again with the year 1839, we find Talbot making a short communication to the Royal Society on March 21, the title of which is, *Note respecting a New Kind of Sensitive Paper*. In using bromide of potassium instead of sodium chloride the author finds that greater sensitiveness is manifested. He also refers to a mode of making a negative design on glass by blackening the same by means of the smoke of a candle, and etching out the lines by means of a needle point.

The ninth meeting of the British Association was held at Birmingham in 1839. It opened its proceedings on the 29th of August, ten days after the public announcement of Daguerre's method. Accordingly, we find Talbot contributing a paper to the section of physics and mathematics, dealing with the Frenchman's discovery, *Remarks on M. Daguerre's Photogenic Process*. Talbot's paper is for the most part taken up with the consideration of the optical phenomena presented when a particle of iodine is laid on a silver plate and afterward gently treated. He seems, moreover, to doubt the superior sensibility of Daguerre's plate over his photogenic paper. The discussion that ensued is reported in No. 618 of the *Athenæum*, August 31, 1839.

Up to this point, as we have seen, Talbot had been busying himself with the obtaining of actual images—"printed out" subjects, as we would now call them. Talbot's own words, referring to his calotype process, may be here quoted. They are taken from the appendix already alluded to. "The discovery of the latent image and the mode of its development was made rather suddenly on September 20 and 21, 1840. This immediately changed my whole system of work in photography. The acceleration was so great, amounting to fully one hundred times, that, whereas it took me an hour to take a pretty large camera view of a building, the same now only took about half a minute, so that, instead of having to watch the camera for a long period, and guard against gusts of wind and other accidents, I had now to watch it for barely a minute or so. Portraits were now easily taken in moderate daylight. One of the first portraits taken was sent to the French Academy of Sciences, where it excited great interest, and was passed from hand to hand, and afterward to the public in the galleries, my friend Monsieur Biot being my informant.

"I soon drew up an account of this new process, which I named the calotype, and transmitted it to the Royal Society."

The memoir in question was read at the Royal Society meeting of June 10, 1841, its title being *An Account of some Recent Improvements in Photography*. The process, briefly stated, consisted in forming silver iodide, in the first instance, on the surface of paper, sensitizing thereafter by means of gallo-nitrate of silver, developing the image after exposure by further applications of the gallo-nitrate solution. The fixing was effected by means of a soluble bromide. The process was patented in February, 1841, but in 1852 Talbot, with certain reservations, gave the right to work it to his countrymen. Specimens of early calotypes I have here with me, and can be inspected afterward. The calotype, or talbotype, was a negative picture, the positive reproduction of which was obtained by means of his photogenic paper. By a modification of his process Talbot worked out a method whereby positives were secured in the camera. The *modus operandi* was as follows: Sensitized calotype paper was exposed to sunlight till a visible browning took place; afterward it was dipped into a solution of potassium iodide (twenty-five grains to the ounce), washed in water, dried with blotting paper, and a good full exposure given in the camera. Development by means of the gallo-nitrate solution was then resorted to, when a positive reproduction was obtained. I pass a camera picture round secured by this method.

In 1842 the Rumford gold medal was awarded Talbot in recognition of his photographic discoveries. At the Cork meeting of the British Association in 1843, Talbot was asked by the general committee "for his report on photography and its applications to be presented, if possible, at the next meeting." The report asked for does not appear, but we find a communication from Talbot detailing his experiments on sulphate of iron as a developer in his calotype process. As is well known, the proposal to use ferrous sulphate emanated from Robert Hunt. The short abstract of Talbot's paper will be found at page 105 of *Report of Transactions of British Association* for 1844.

In 1843 Talbot was over in Paris for some little time, giving lectures and demonstrating his process.

In 1844 the first part of the famous *Pencil of Nature* made its appearance. Its publication extended over a period of two years, several unforeseen difficulties having been met with. There were six parts in all, and twenty calotype illustrations in the complete work. In 1845 another work was published having similar photographic illustrations, with the title of *Sun Pictures in Scotland*. Both works are here for inspection of those interested. In 1846, in the *Art Union* number for June 1, an article entitled "The Talbotype Sun Pictures," evidently inspired by Talbot, forms the first contribution. As a supplement a calotype was furnished with each number. There must be still extant a goodly number of these pictures hidden away in old bookstalls and in libraries. The original issue was something like 7,000, and a large number of negatives seem to have been employed. In all those reproductions which I have seen I have not yet met with a duplicate. I have with me for inspection two of these early talbotypes.

In June, 1851, a remarkable experiment was performed by Talbot, at the Royal Institution. A printed paper was attached to a wheel, which was made to revolve rapidly in the dark. On illuminating the paper for a very brief interval of time, by means of the electric spark, a photographic transcript of the printed matter was obtained on a plate prepared by a method described in the *Athenæum* of December 6, 1851. The process was patented by Talbot.

In 1852, Talbot secured a patent for photo-engraving. He gave the name of photoglyphy to his method, and made use of the well-known action of light on bichromated gelatine, the etching of the plate being performed by means of iron perchloride. A subsequent patent was taken out in 1858, the improvement consisting in the application of a resin to the plate before commencing etching operations.

A supplemental illustration of this mode of engraving was issued with No. 10 of the *Photographic News*, appearing November 12, 1885. Several plates were employed to give the necessary number of prints for the circulation of the paper; we find, therefore, that the subjects depicted are somewhat varied, and they are mostly Continental.

A more perfect illustration appeared with No. 54 of the *Photographic News*, September 16, 1859 (vol. iii.). In this supplement there was only the one subject chosen, a view of a portion of the Tuileries. The plate which furnished the proofs was copper, and had been steel-faced. I regret that I am not in a position to

show specimens illustrative of Talbot's photo-engraving. A specimen of a half-tone engraving appears in a second edition of Tissandier's *Photography*, already referred to, as also a specimen of line work.

These, as I have the book with me, can be seen. Several other patents connected with photographic applications were applied for. We need only refer to one taken out in conjunction with Malone for the use of unglazed porcelain instead of glass, and employing an albumen process.

Enough has been said to show how very assiduously Talbot must have worked at the various photographic methods he from time to time brought forward; but other scientific matters engaged his attention as well. It would be beyond the limits of this communication to enter into these. We are only more immediately concerned with the facts which we have just glanced at. I regret that the marshaling of these had not fallen into the hands of one more capable of rendering full justice to them. It will be our privilege, as a convention, to visit the shrine of Lacock Abbey, where the illustrious Talbot worked, and surely that "building which was the first that was ever known to have drawn its own shadow," to use Talbot's own expression, must have an interest and significance to the photographic pilgrim which to the ordinary visitor will be completely wanting.

POSTAGE STAMP PHOTOGRAPHS.

It sometimes happens that a person needs to have it within his power to make use of a large number of photographs, and if he had to give these the usual dimensions the cost would often be too great for the object proposed. He will then be satisfied with a very reduced size—that of a postage stamp—and he will thus have a very large quantity at a very little cost, that he may distribute without stint.

There are different methods employed for obtaining these small images, and some of them we propose to make known. Here is one that we have been made acquainted with by Mr. Francis, of London, from whom we borrow a specimen of his work (see accompanying figure). Each "postage stamp" costs about one cent. The stamps are separated from each other by perforations in the paper. They are gummed on the back and can be made to adhere to a piece of card board or a visiting card, or may form a letter heading, etc.

POSTAGE STAMP PHOTOGRAPHS.

Mr. Francis operates as follows: He takes the photograph to be reduced and surrounds it with any style of ornamental border. This done, he places it in front of a camera and illuminates it by means of two gas jets giving a very strong light. The objective employed should be of short focus, and behind it there is placed a screen provided with an aperture of the size of a postage stamp. This screen may be arranged in the camera in front of the sensitized plate, and is mounted in such a way that it can be easily displaced. Having begun by placing the aperture opposite the upper left hand corner of the plate, for example, the operator takes the first negative of the photograph to be reproduced, and then he slides the screen along in such a way as to displace the aperture to a degree equal to its width, and takes a second negative alongside of the first.

Through successive displacements of the screen, a dozen negatives are thus taken upon a quarter of a plate. Naturally, it is necessary to make an exposure for exactly the same time for each of them, so that the development shall be effected regularly for the entire plate. It is probable that in measure as the screen is displaced, it is necessary to displace the objective likewise. The negative thus obtained is printed upon ordinary albumenized paper, and then gummed upon the back and perforated by means of a special machine, as in the case of postage stamps.

Having described Mr. Francis' process, we shall describe some other modes of operating.

When one has several photographs at his disposal, say a dozen album size cards, he may pin them alongside of each other to a wall and take two or three negatives of the whole. The printing can then be done very quickly. On a fine day it is possible to make a hundred small positives. By this process we have reproduced the portrait of a deceased person, the only photograph of whom existed in the picture of a group. We began by cutting out a perfect silhouette of the head that we wished to reproduce, in order to conceal the rest of the image, and then we made an enlarged negative of the head. This we touched up a little, and printed six positives on sensitized paper. We then operated as we have just stated, and, from four negatives, obtained a hundred and fifty positives by the end of the day.

There is still another process that would give excellent results. It would suffice to make use of the American apparatus with which certain operators, especially at market fairs, take ferrotypes. This apparatus consists of a camera provided with twelve objectives, all alike, which give twelve images at the same time upon the plate. In this case a single negative of the image to be reproduced would suffice, and this is certainly the best method of obtaining quick results. But amateurs do not usually own apparatus of this kind, and it is to them that we especially address ourselves. We leave to them the selection of a method from among those that we have just described.—*La Nature.*

RECENT DEVELOPMENTS IN PRINTING PROCESSES.*

By C. H. Bothamley, F.C.S.

Later developments of printing processes have proceeded along certain well marked lines, the one common aim being to render the use of albumen unnecessary, and in view of the want of permanency that characterizes albumen prints, it will be admitted that the attainment of this result is much to be desired. For some time the development was all in the direction of the production of prints with a black or even blue black color, and we were affected with one of those attacks of artistic cant from which photography suffers now and again. It was urged that, quite apart from any advantage of greater permanency, the new prints are much more artistic, simply because they are black. The preachers of this faith seem to have forgotten that etchings and mezzotints, to say nothing of photogravures, are very rarely printed in black, and that some of the most famous etchers and mezzotint engravers have printed in very warm browns, and, at times, in red browns. Now I, for one, decline to admit that a black print is necessarily more artistic than a brown print, simply because the one is brown and the other is black, and I welcome the still later tendency toward the production of prints with warmer colors, provided always that the prints are permanent.

Methods for the production of prints with warm colors, such as gelatino-chloride paper, Alpha paper, and Lionel Clark's silver toning, are too familiar to require more than passing mention, and I propose to speak in detail of only two or three methods, which are based either on novel principles or on principles that have not hitherto been successfully applied in practice.

Platinotype has long been regarded as the first of the black printing processes, but the present very high price of platinum has stimulated investigation in the direction of replacing the platinum by some cheaper metal, that will produce prints of the same character, and, as far as possible, with the same degree of permanence. So far, the only important outcome is the process that is known as kallitype, which in principle is precisely similar to the platinum process, except that the image is formed of metallic silver instead of metallic platinum.

Kallitype is based upon the old observations of Herschel and of Hunt, that when ferric tartrate, citrate, or oxalate is exposed to light, and thus reduced to a ferrous salt, and the ferrous salt is treated with a solution of silver nitrate, metallic silver is precipitated in quantity dependent on the quantity of ferrous salt that has been formed on each part of the surface. Until quite recently these facts had not been utilized, but Dr. W. W. J. Nicol, working with a full knowledge of the chemical changes involved, has succeeded in producing a practical printing method by making considerable alteration in the details of the process. Kallitype, in fact, is an excellent example of the way in which an old observation, apparently of little practical value, may become of very great utility in the hands of a man who has sufficient knowledge of chemical and other principles to develop it in the right direction and in the right manner.

The details of the process, as first published, are to be found in the patent specification No. 5,374, February 15, 1890 (*The British Journal of Photography*, XXXVII., 170, 171; *Photographic News*, XXXIV., 207). Paper is coated with a solution of ferric citrate, ferric tartrate, ferric oxalate, or mixtures of all or any of them, and is dried. It is then exposed behind a negative until a faint image is formed, just as in platinotype, and the image is developed by treating it with a solution containing 10 per cent. of sodium citrate, and sufficient ammonia to just keep the silver in solution. The patentee recommends a solution containing 1·5 per cent. of silver nitrate, but I find that better results are obtained with only one per cent., and the best method of making up the solution is to dissolve the silver nitrate in a small quantity of water, and dilute ammonia very carefully until the precipitate formed is just, and only just, redissolved, then add the sodium citrate, previously dissolved in five or six parts of water, make up to the required volume and filter. It is also recommended that a very small quantity of potassium dichromate should be added. The sodium citrate has the double function of dissolving the ferrous salt, and thus enabling it to reduce the silver nitrate, and of preventing precipitation of the iron by the ammonia. After development the print is immersed in a 20 per cent. solution of an alkaline tartrate or citrate, made strongly alkaline with ammonia, and afterward in two successive baths of a dilute solution of sodium citrate, containing free ammonia. The alkaline tartrate or citrate removes the iron compounds, while the ammonia removes the silver compounds, and finally the prints are washed in water.

The chief objection to this process was the use of silver compounds in the developing solution, which, of course, was very liable to stain the fingers of the operator, and quite recently a modification of the process has been made, which not only removes this objection, but also enables prints to be obtained with a very warm color. The silver salt is in the paper instead of being in the developer, and it is interesting to note that the modifications in kallitype have followed the reverse order to the modifications of platinotype; in the latter, the platinum was at first in the paper, but in the latest modification it is in the developer.

The specification of the patent of kallitype No. 2 is not yet published, but Dr. Nicol has kindly informed me that the paper is coated with a solution containing ferric oxalate, ferric nitrate, silver oxalate, silver nitrate, and nitric acid. It must be kept as dry as possible, but does not require the same minute precautions as the old platinotype paper. The pads, etc., of the printing frame must also be dry. My own experience leads me to the conclusion that care in this matter of keeping the paper dry is of very great importance.

The paper is exposed until the detail in the densest parts of the negative is very faintly indicated, the appearance of the image being very much the same as in platinotype, and it is then developed, the composition of the developing solution varying with the color required in the finished print. For *black prints* the exposed paper is immersed in a solution containing 10 per cent. of Rochelle salt, and 10 per cent. of borax; for *purple prints*, 10 per cent. of Rochelle salt, and 2 to 5 per cent. of borax; for *sepia prints*, 5 per cent. of Rochelle salt, 1·25 per cent. of borax, and a small quantity of hydrochloric acid. In all three cases a small quantity of a dilute solution of potassium dichromate must be added. The dichromate keeps the whites clear, and increases the contrasts, and the character of the prints can be altered by varying the proportion of this salt; too high a proportion destroys the half tones. The examples shown demonstrate this point very clearly; in each case two prints were made of as nearly as possible the same intensity, and one was developed with a solution containing no dichromate, the other with a solution to which the dichromate had been added.

The prints are all allowed to remain in the developing solution for some time, in order that the Rochelle salt may remove the iron from the paper; and the excess of silver salts is then removed by immersion for about fifteen minutes in water, eighty parts, strong ammonia solution, one part. The prints are afterward washed in water.

My own experience indicates that, even after prolonged immersion in the developer, there is danger of iron salts remaining in the paper, with, of course, loss of purity in the whites, and I recommend that after removal from the developer the prints should be immersed in a 10 per cent. solution of Rochelle salt before being put into the ammonia. After the Rochelle salt has been used frequently for this purpose, it may be utilized for making up fresh developing solution.

The black prints have a good color, with a very slight bluish tinge, the whites are clear, and the gradations good.

The sepia prints are not so satisfactory, the color is often too red, and is sometimes not uniform throughout the print. It seems, in fact, that it is more important in this case that the paper should have been kept thoroughly dry. Prints should be somewhat deeper than for the other developers, and the developer, if used frequently, must be kept acid by addition of a few drops of hydrochloric acid.

The permanence of the kallitype images is of considerable interest. The black images by both the first and second method are not altered by exposure for forty-eight hours to the products of the combustion of sulphur in air, nor by an immersion in a solution of sulphurous acid for the same length of time. A solution of sulphureted hydrogen, if dilute, changes the color to bluish black, but produces no other alteration; if the solution is strong, the bluish black image undergoes a further change, and becomes brown. A dilute solution of ammonium sulphide changes the color to brown, with no loss of detail and not much loss of intensity; the brown color thus produced is very suitable to certain subjects.

The sepia paper, likewise, seems unaffected by the products of the combustion of sulphur; sulphureted hydrogen or ammonium sulphide first changes the sepia image to black, but it afterward becomes gradually brown.

No prolonged experiments on the behavior of mounted prints have as yet been possible, but there is no reason to doubt that under ordinary conditions kallitype prints are permanent. It is, of course, not to be expected that kallitype can as yet equal platinotype, but it is by no means improbable that in time the difference will be chiefly a possible difference in permanency. The process is already capable of giving very good results, and it is considerably cheaper than platinotype.

The other processes that I shall describe belong to an entirely different class. They are the first practicable photographic processes based on the use of coal tar colors. Both processes depend upon the formation of azo coloring matters from diazo compounds, and they may be spoken of as *diazotype*, but they differ in the nature of the change that the light produces and in the condition under which the coloring matter is formed.

Diazo compounds are a class of compounds characterized by their power of uniting with carbolic acid or any other phenol, any naphthol, or any amine to form an

* Read before the Photographic Convention, Bath, July, 1891.

azo coloring matter, the tint of which depends on the nature of the diazo compound and also on the composition of the particular phenol, naphthol, or amine. Yellow, orange, brown, purple, scarlet, and blue may be cited as examples of the variety of color that can be obtained in this way.

Feertype is the first of these processes, and is so called from the inventor, Dr. Adolph Feer (German patent 53,455, December 5, 1889). It is based on the fact that diazo compounds, in contact with acid sulphites, form diazo sulphonic compounds, and these form no coloring matter. If, therefore, a diazo sulphonic compound is mixed with an equivalent quantity of a phenol or an amine, no coloring matter is formed. If, however, the mixture is exposed to light, the diazo sulphonic compound is decomposed, the diazo compound is set free, and since a phenol or amine is already present, a coloring matter is formed as fast as the diazo compound is liberated.

The process is applicable both to paper and to textile fabrics. The paper or fabric is coated with a solution of a diazo sulphonic compound of high molecular weight, mixed with an equivalent quantity of a phenol, or a naphthol and an alkali, or with an equivalent quantity of an amine and an acid. The patent specification recommends sodium, ditolyltetrazo-sulphonate, but Feer has since recommended sodium diazopseudo-*cumidine* sulphonate, which can be obtained from Dr. Schuchardt, of Gorlitz. My own experiments, which are as yet but few in number, were made with this compound and β naphthol. An exposure of ten seconds to comparatively weak sunlight produces a very decided quantity of coloring matter, and an exposure of a very few minutes gives a deep colored print. The rate of formation of the coloring matter decreases as the exposure continues, because the coloring matter formed in the superficial layer acts as a screen to the unaltered material behind. The light from burning magnesium will also produce a print, and prolonged exposure to gaslight will produce an easily recognizable amount of coloring matter. Some "nature prints" from fern leaves are exhibited. They show a very considerable amount of detail as well as the outline.

The Primuline Process is the second process of this class, and is the invention of Messrs. Green, Cross & Bevan (English patent 7,453, May 13, 1890). Primuline was first made by Mr. Green, and is a yellow coloring matter that contains sulphur. It has the peculiar property of dyeing cotton, linen, paper, or any other material consisting of cellulose, without the use of a mordant. The exact constitution of primuline is not yet known, but it contains an amido group, and, therefore, will yield a diazo compound, which in its turn will form coloring matters. Diazo primuline in the pure, solid state is practically unaffected by even prolonged exposure to light, but when in contact with cotton, linen, or cellulose, it is rapidly decomposed by light, with complete destruction of the diazo compound and consequent loss of the power to form coloring matters.

The primuline process is applicable to fabrics as well as to paper, and gives better results with the former. Herein, in fact, lies its special merit. Fine calico, linen, etc, free from grease, is immersed for a short time in a boiling solution of primuline (about 3 parts in a 1,000) containing a small quantity of common salt, and is then washed with water. If necessary, it may at this stage be dried, and will keep for any length of time. In order to sensitize the material the primuline is converted into diazo primuline by immersion for a short time in a dilute solution of sodium or potassium nitrite (1 part in 400), acidified with hydrochloric, sulphuric, oxalic, or some other acid. It is then washed and dried in the dark without the aid of heat. If made too dry, the material becomes less sensitive.

The sensitive material is exposed in an ordinary printing frame, a very short time being required in bright sunlight, but a much longer time in a dull light. Since the correct time of exposure cannot be judged by mere inspection, a strip of the same material is exposed outside the printing frame, and is touched from time to time with a drop of the developing solution. When the latter ceases to produce any color, the diazo primuline on the test strip is completely decomposed, and it may be taken that decomposition in the high lights of the transparency is also complete. The print is then ready for development, which is effected by immersing the print in one of the following solutions: For *yellow*, phenol; for *orange*, resorcinol; for *red*, β naphthol; for *maroon*, β naphthol disulphonic acid. One part of the substance is dissolved in 400 parts of water, made alkaline with caustic potash or caustic soda. Other developers are: For *brown*, metaphenylenediamine; for *purple*, alpha naphthylamine; for *deep blue*, eikonogen. The eikonogen is dissolved simply in water; the two amines are dissolved in water acidified with hydrochloric acid. Different developers—stiffened, if necessary, with starch—may be applied with a brush to different parts of the same prints. The developed prints are washed with water, and, in the case of the blue and purple developers, the last wash water should be *slightly* acidified with tartaric acid. In other cases the prints are improved by being washed with soap and water. In all cases the appearance of the print is improved if, after removal from the printing frame, the back of the print is exposed to light for a short time in order to secure complete decomposition of the diazo primuline in the high lights. The ground of the prints always remains pale yellow, and at present no method has been discovered by which a white ground can be obtained.

In feertype the quantity of coloring matter formed is proportional to the quantity of light action, and hence we obtain a positive from a negative, and *vice versa*. In the primuline process the quantity of coloring matter is *inversely* proportional to the amount of light action, and hence we get a positive from a positive and a negative from a negative.

The prints being formed of azo coloring matters will gradually fade if exposed to sunlight, but are permanent enough if exposed only to the diffused light of ordinary rooms.

Neither of the diazotype processes is at all likely to displace any of the ordinary printing processes, but they may be specially useful for the copying of engineers' plans, etc., upon cloth, and, since a variety of colors can be obtained, the processes are likely to be very useful for decorative purposes. The primuline process is very simple and cleanly, and can be readily used by ladies, who, with the help of dried ferns and other leaves, can produce a great variety of designs on linen, etc., and these can be mounted in any desired manner. In this connection it may be useful to point out that the disagreeable smell of the purple developer (alpha naphthylamine), which clings very tenaciously to the fingers, can be removed by dipping the fingers into the solution of nitrous acid used for sensitizing the primuline.

During the course of his lecture Mr. Bothamley demonstrated practically to the meeting the various chemical changes which took place by the variation of the dyes used in the two latter processes, and also developed one or two kallitype prints. In reply to inquiries he said he could get a great variety of colors with kallitype, but it varied considerably so far as the exact tint of sepiatype was concerned.

PURIFICATION OF WATER FOR INDUSTRIAL PURPOSES.

THE great importance that the question of the purification of water designed for industrial purposes has now assumed is well known. Applied at first almost exclusively to water for feeding steam boilers, it has gradually been extended to the various branches of the industries in which water plays some role or other, either as a mechanical or dissolving agent aiding in the production or as a compound entering into combination in manufactured products.

There are few industries in which, from various standpoints, it is not of interest to employ pure water. We well know the benefits derived from it in the feeding of steam boilers. In the washing of linens and in bleacheries, a great saving of soap is obtained, this being estimated (on an average) at from 300 to 400 grammes per cubic meter of water employed. In dyeing and finishing, it permits of reducing the consumption of mordants, while at the same time increasing the richness of tones and shades. In sugar works and refineries, the use of pure water effects a saving in the parchment for osmosis and an increase in the rendering of the waters of diffusion. In distilleries, there are obtained clearer bleudings of alcohol and a suppression of incrustations in the condensers. In breweries and in the manufacture of tannic and dyewood extracts, work is found to be greatly facilitated by the use of purified water, along with a larger rendering in extracts. We here end these citations, which will suffice to show the high importance of the researches made upon purifiers.

Mr. Henry Desrumaux, pursuing researches in this direction, has succeeded in devising a purifier which is now being exploited with success by a society called "L'Epuration des Eaux Industrielles," and which in practice gives excellent results. While offering complete security from the immediate standpoint of purification, this apparatus at the same time operates practically. Moreover, its automatism renders it independent of hand labor and surveillance.

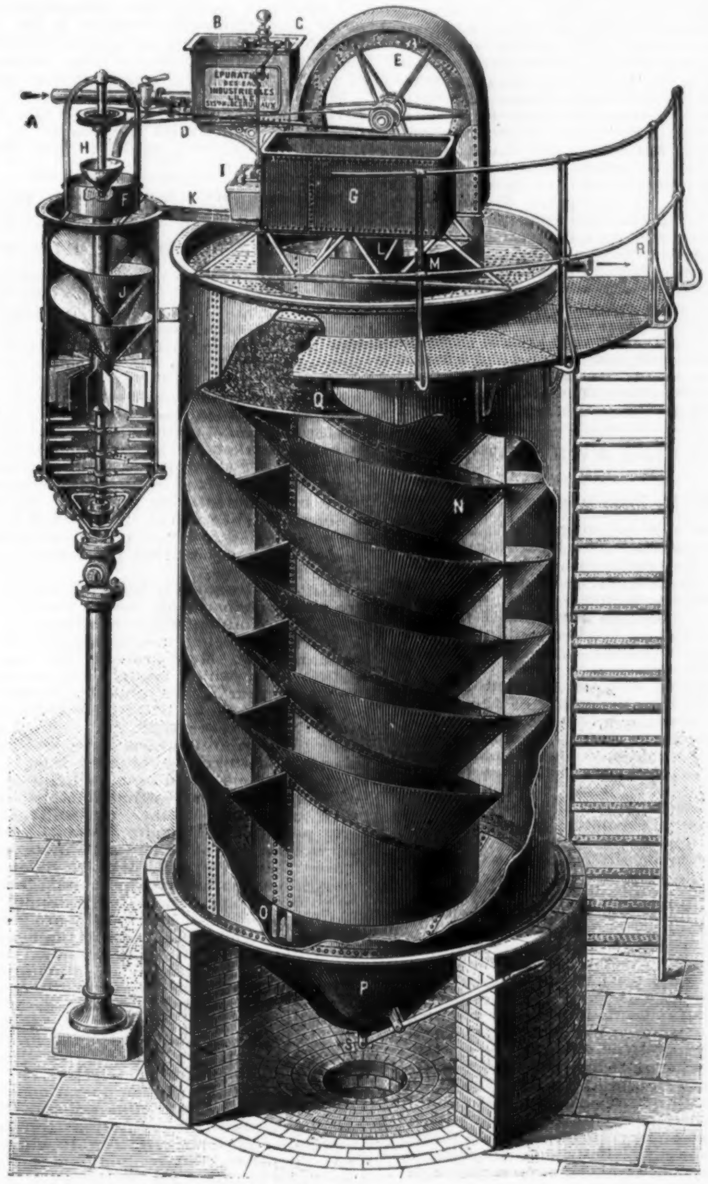
We present herewith a general view showing the interior arrangements of this purifier, by means of which the two following very distinct conditions are to be satisfied: (1) the precipitation of the pernicious salts that the water holds in solution; (2) the separation and complete elimination of the precipitates formed.

Several reagents added to water to be purified, in proportions regulated beforehand by analysis, serve, as well known, for the precipitation of injurious salts. In the present case, it is lime water that is generally employed, and this is prepared in a saturator or automatic stirring apparatus. In certain cases, soda and a solution of iron are also employed.

As for the separation and the elimination of the precipitates due to the chemical reactions, these results are obtained by means of a decanting apparatus with helicoidal surfaces.

The saturator consists of a cylinder, J, whose conical bottom is provided with a mud hole. Its hollow axle is provided with paddles at its lower extremity and is actuated by the overshot wheel, E.

The decanter consists of two concentric cylinders of unequal heights. In the internal one, M, which is open at both extremities, the reactions are effected. The external one, which is surmounted by a shavings filter, Q, has a conical bottom, P, with a mud valve. The conoidal and helicoidal plates are provided with vertical diaphragms constituting deposit chambers, that communicate with one of the mud collectors, O, through apertures at the intersection of the partitions, in order to assure of the flow of the mud at P. We shall now explain the operation of this apparatus, in referring to the accompanying figure.



APPARATUS FOR THE PURIFICATION OF WATER.

The liquid to be purified enters the regulator, B, at A, where it is kept at a constant level by a float valve. A cock, D, and a valve, C, regulate the distribution of the water to the automatic saturator and to the overshot wheel, E, which sets it in motion.

The water used in the preparation of the reagent is emptied by the funnel, H, into a hollow vertical axle, reaches the bottom of the saturator and makes its exit through a journal, and becomes intimately mixed with the lime contained in the mixing vessel. The lime is placed at regular intervals (once a day at a maximum) in the receptacle, F, which, at its center, is provided with a perforated plate designed to separate the stones from the lime employed. The lime descends into the mixing chamber through the internal cylinder. The water, through the motion of the paddles that it meets with in ascending, becomes saturated with lime, and as it pursues its upward motion is rapidly decanted. The deposits that it abandons fall upon the helix, J,

which carries them to the saturator, where they are converted into the state of milk of lime, until complete exhaustion. Between the helix and the saturator there is a series of fixed partitions radiating from the center to the circumference, and which have the effect of facilitating the decantation by arresting the eddies due to the revolution of the paddles.

The water, saturated with lime and perfectly decanted, makes its exit at the top of the saturator, and through K reaches the decanter. Opposite the motive wheel is situated the soda reservoir, G, the discharge of which is regulated by the float, I. The soda regulator is connected with the water regulator, so that the flow of the soda ceases as soon as the entrance of water is interrupted.

The liquid to be purified and the reagents enter the small mixing back, L, overflow into the reaction column, M, and descend toward the lower part of the apparatus. The water at the end of this first passage gives up the heaviest deposits, which fall to the bottom, O, of the decanter. Passing under the edge of the internal cylinder, the liquid afterward begins an ascensional motion and is distributed through the various spirals.

The spirals, N, have the effect of separating the liquid into movable strata of slight thickness, in such a way as to reduce the height of fall of the precipitate, and consequently to hasten the purification. They at the same time force the water to circulate in distinct veins, separated from one another by full strata, so that the deposits abandoned by the upper portions of the liquid cannot, on descending, pollute the portions in the lower spirals in the act of becoming clarified. As for the deposit of the precipitate, that is naturally favored by the very form of the surfaces of decantation. In fact, the liquid, by virtue of its ascensional motion, enters the helix and continually follows the upper region of the spirals, while the lower spaces are occupied by the deposits, which thus move freely over the helicoidal surfaces, independent of the force due to the velocity of ascension. The deposits descend to the mud reservoir, whence they are removed by opening the mud cock, P, and keeping it open until clear water makes its appearance. The liquid, freed from all the precipitated salts and all solid substances that polluted it, lastly traverses a filter, Q, and makes its exit clear and limpid from the decanting apparatus at R.

The numerous applications made of this purifier in various industries testify to the qualities of the system. Some idea of their importance may be had when it is known that the apparatus is now being employed for the treatment of 500, 800, 1,000, and even 2,000 cubic meters of water a day.—*Revue Industrielle.*

COTTON BLEACHING WITH OXYGENATED WATER.

By M. PRUD'HOMME.

THE addition of calcined magnesia to oxygenated water has been recommended for bleaching cotton, but the superiority of the results obtained has not received any explanation. It depends, as I am about to show, on the formation of magnesium peroxide, which at 100° is more stable than hydrogen peroxide.

1. Oxygenated water at 6 volumes, diluted with 10 parts of water, was boiled for half an hour; its standard fell from 1,000 to 100.

2. A similar quantity, with the addition of calcined magnesia (5 per cent. on the weight of the hydrogen peroxide), falls in strength only to 900.

3. Calcined magnesia is placed in contact with oxygenated water at 3 volumes, at the ordinary temperature. The duration of the contact varies from some hours to many days. It is filtered, washed on the filter, and the product dried at from 100° to 105°.

The determination of the active oxygen by means of a normal solution of potassium permanganate corresponds to the formula $3\ Mg(OH)_2 + MgO(OH)_2$. This body, by an alkaline reaction, loses all its active oxygen at about 300°.

Magnesium peroxide is also formed on dissolving the metal in oxygenated water. Weltzein considers the product of the reaction a soluble magnesium hydrate. It is easy to show that when evaporated to dryness it gives with the ordinary tests the well-known reactions of oxygenated water.

The oxides of zinc and cadmium (metals belonging to the same series as magnesium in Mendeleeff's classification) also give rise to peroxides.

The mixture of zinc oxide and peroxide corresponds approximately to the formula $2\ ZnO + ZnO(OH)_2$.

Cotton bleaching with oxygenated water would remain unintelligible if we confined ourselves to consider it as a simple decolorizing agent. It has a direct action upon the different bodies which bleaching has to modify or to eliminate, and even upon cellulose.

Action upon Fatty Bodies.

The saponification of the oils or fats is effected in part by the magnesia, but it is also due to the direct action of the oxygenated water. During ebullition there takes place an abundant liberation of carbonic acid; it may be derived from the oxidation of the glycerine, as it is verified directly. But the oxygenated water, very faintly acid, attacks also the neutral fatty bodies at ebullition, with the liberation of carbonic acid and a formation of fatty acids. These again are transformed by the mixture of oxygenated water and of calcined magnesia, and always with the production of carbonic acid. This happens with the stearic and the oleic acids of commerce. There must occur a partial transformation of this latter body into palmitic acid (as if by the action of potassa lye), for the product of the reaction, if suitably treated with an acid, is richer in soluble fatty acids than the oleic acid of which it forms a part.

The fatty bodies which remain upon the fiber in the state of magnesium oleates, palmitates, etc., are eliminated by a passage in weak acid, followed by an alkaline lye.

Action upon Cellulose.

In bleaching with oxygenated water the cellulose tends to become converted into oxycellulose. This is easily recognized by dyeing in basic coloring matters which fix themselves without a mordant upon oxycellulose.

The modification of the cellulose is more strongly marked if it has been *mercerized, i. e.*, saturated with concentrated caustic soda before treatment with oxygenated water. The disaggregation becomes complete, and the tissue becomes a pulp if we add caustic soda to the bath of oxygenated water until it marks 6° to 8° Tw.

The action of oxygenated water upon cellulose is much increased by the presence of certain bodies, such as metallic oxides, which serve merely as a vehicle or intermediate agent for active oxygen. A swatch of cloth mordanted with iron, chrome, or alumina, and boiled with oxygenated water or magnesia for one to two hours, is profoundly attacked at the parts covered by the mordants. It is well, therefore, to let a treatment with weak acid precede the bleaching with oxygenated water, to eliminate the salts or the metallic tissues from the tissue.

The action of oxygenated water and that of cuprammonium upon cellulose present great analogies.

It is easy to show that the ammoniacal solution of copper oxide is an oxidizing agent, by allowing it to act upon a swatch dyed blue with indigo. The solution, if sufficiently diluted to produce no sensible alteration of the tissue, decolorized the blue in 24 hours in the cold and in a few minutes at 60°. If the cuprammonium solution is sufficiently concentrated to weaken the fiber, this, if well washed and treated with a dilute acid to dissolve out the copper oxide, takes up a full shade on methylene blue; there is therefore a formation of oxycellulose.

A swatch of cotton cloth mercerized in caustic soda at 36°, and thoroughly washed, is left in contact for some hours with a cuprammonium solution of medium concentration. The fiber is more attacked than that of a check swatch which has not been mercerized.

We conclude from these experiments that, contrary to the received opinion, cellulose is attacked and transformed by contact with the reagent of Schweitzer.—*Comptes Rendus* (cxii., p. 1374), *Chem. News.*

THE MANUFACTURE AND INDUSTRIAL VALUE OF ALUMINUM.*

By J. H. J. DAGGER, F.I.C., F.C.S.

IT is little over five years ago since I had the pleasure of being present for the first time as a member of this society, and then listening to a paper read by our esteemed treasurer on what he very truly termed a new departure in metallurgical science—the application of electricity to the reduction of metals from their ores. As in all things new, greater expectations were formed than have been realized; still, the electrical furnace then described marked the first step in the production of aluminum at a cost that would place it in the market beside the common metals, and also the raising of electrolytic and electrothermic methods from laboratory and lecture table experiments to the rank of manufacturing processes. Before passing to a description of some of these, it will be interesting if for a moment I give you in outline the history of this, one of the most beautiful and destined to be most useful of the metals.

History.—Its name is from *alumen*, the word given by the Romans to all bodies having an astringent taste, hence alum, which is alluded to by Pliny and Vitruvius as being used as a mordant in producing brilliant dyes. Most probably this was "kalinite," a potash alum which occurs in large quantities in the Solfatara, near Naples, probably formed by the action of volcanic gases on feldspathic trachyte. It was not until 1746, however, that Pott first stated the base of alum to be an argillaceous earth, and eight years later Margraff distinguished alumina from lime, with which up to that time it had been confounded. In 1807 Davy made an unsuccessful attempt to decompose alumina with the electric current. In 1824 Oersted obtained a gray powder which oxidized rapidly in the air by heating aluminum chloride with potassium amalgam. Three years later, 1827, Wohler, by decomposing the anhydrous chloride with potassium, obtained a metallic powder which became bright under the burnisher, but it was not until 1845 that he produced the metal in the form of globules as large as pin heads. From these he, with infinite patience, determined for the first time the physical characteristics of aluminum.

In 1854 Deville and Bunsen, working independently, obtained aluminum by electrolysis of the fused chloride, and the same year Deville, substituting sodium for potassium, obtained the metal in quantity for the first time by the well known process which, until the recent development of electrolytic methods, has formed the basis of the operations for the production of aluminum at Salindres, and the more recent developments of the industry at Newcastle and Birmingham in our own country. It will, perhaps, not be forgotten that the first aluminum in this country was produced in 1855 in the laboratory of the Royal School of Mines, by Messrs. Dick and Smith, under direction of Dr. Percy, by the action of sodium on cryolite.

Gerhard established a factory at Battersea in 1859, and Messrs. Bell Brothers at Newcastle, 1865, produced aluminum by the Deville method, but neither of these undertakings proved successes commercially, and after a time were abandoned.

The next stage in the development of the aluminum industry was the improvement and simplifying of the sodium methods by Castner and Netto, both of which processes have been described in the *Journals* of this society, as also the well known Cowles process for production of alloys, which I described at length in a communication to the society in September, 1889.

The advance of electrical science has given us an increased knowledge of the laws of electrolysis, and the improvement in dynamos and electrical machinery has within the last two years reduced the cost of aluminum from 15s. to 5s. per pound. The price of aluminum having fallen from 360s. 1855, 108s. 1857, 62s. 1860, 20s. 1862 to 1887, 15s. 1888, 5s. 1890-91. Any further reduction in price will be rather from improved methods in the production and purification of alumina, for the exceeding difficulty of obtaining the metal free from silicon and iron has been and still remains an obstacle in the way of its cheap production, greater than we have to deal with in the case of other metals. Although aluminum is one of the most widely distributed of the elements, the necessity of using alumina free from impurities reduces the number of minerals available in our present state of knowledge to very few. These are:

Bauxite, preferably that from Beaux, in the Department of Var, of which the following are typical analyses:

—	Red.	White.
Al_2O_3	60·73	64·83
Fe_2O_3	20·08	·05
SiO_2	3·62	12·60
TiO_2	1·91	3·44
P_2O_5	0·39	..
H_2O	13·27	15·47
	100·00	99·99

Corundum.—Very hard crystalline mineral, sp. gr. 3·909, occurs massive in northern Georgia, and in India, often as water-worn pebbles in *debris* from river torrents. Here is an analysis of such pebbles from Ceylon and of rock from India, locality unknown:

—	Pebbles.	Rock.
Al_2O_3	89·23	84·26
FeO	0·77	..
Fe_2O_3	..	0·73
SiO_2	5·55	11·77
TiO_2	4·88	3·31
CaO, MnO_2	Traces	..
	100·43	100·00

Cryolite.—This mineral, a double fluoride of aluminum and sodium, is found in large deposits in one district in Greenland, from which nearly all that is used is obtained. It is found in smaller quantities at Miask, in the Ural Mountains, and near Pike's Peak, California. An average analysis of the Greenland mineral is as follows:

Al	13·23
Na	32·71
F	54·19
Mn_2O_3	0·83

This mineral is not used as a direct source of aluminum, but as a flux in the manner I am about to describe.

Grabau's Process.—Before passing to a description of the electrolytic process for the production of aluminum, I will say a few words about the sodium process as modified by Grabau, of Hanover, in which the difficulties arising from the action of molten alkaline fluorides are overcome in a very ingenious manner, and an aluminum of a high degree of purity is produced. In this process the sodium and aluminum fluoride are heated in two separate iron vessels; the one containing the sodium is provided with a suitable cock for discharging the molten metal, and that containing the fluoride has a drop bottom, or is fitted with a slide that can be readily drawn. A reducing vessel which is kept cool with a water jacket, and which swings on trunnions, is arranged underneath the two vessels. The aluminum fluoride is heated to a temperature of about 600 deg., at which it remains pulverent; the sodium is then melted and run into the reducing vessel. When the metal has all run in, the slide is withdrawn and the pulverent fluoride is allowed to fall on to the sodium; the reaction which ensues produces much heat, and the contents rapidly become fluid; the cryolite produced, however, solidifies on the cool sides of the vessel, and the crust thus formed is not attacked by either the fluid cryolite or the aluminum. The aluminum is collected by rapidly shaking the vessel to and fro, and after a minute or two the vessel is tilted and the contents flow into a lower vessel lined with cryolite or aluminum, leaving a crust of solidified cryolite in the reducing vessel. Notwithstanding the great improvement in the mechanical arrangements and the cheapening of sodium by the recent improvements of Castner and others, it is, I think, only a question of time when the old chemical methods will be superseded altogether by the newer electrolytical processes for the production of aluminum. Even at the present time it is not possible to produce aluminum of equal purity by the use of sodium at anything like equal cost.

I now come to describe the electrolytic processes in operation on a commercial scale for the production of aluminum. They are, first, the Herault process, in operation at the works of the Aluminum Industry Company, limited, at Lauffen-Venhausen, on the Rhine fall, and those of the Societe Electro-Metallurgique, at Froges, near Grenoble. In this process the electrolysis is conducted in iron pots or tanks lined with carbon, the pot is raised on insulating supports, and connected with the cable from the dynamo, so that the lining forms the negative electrode, or else this is made of a piece of metal, iron or copper, fixed in the bottom of the pot. The positive electrode is of carbon and so arranged that it can be lowered or raised in the molten charge. The first charge is a small quantity of cryolite, which is rapidly melted by the heat generated by the resistance to the current. As soon as it is fluid the current passes and alumina is fed into the molten flux. The process is continuous, and the aluminum which accumulates in the bottom of the pot is tapped every twenty-four hours. The purity of the metal produced varies from 97 to 99 per cent. During the operation the oxygen combines with the carbon of the positive pole and produces carbonic oxide, which burns at the vent in the cover to carbonic acid gas.

At Froges the electric current is supplied by four dynamos, each 6,000 amperes, with a voltage of fifteen, worked by two large turbines of 300 horse power each.

At Venhausen are two dynamos constructed to de-

* A paper recently read before the Society of Chemical Industry.—*From the Journal.*

velop 14,000 amperes at thirty volts and a smaller one of 3,000 amperes at sixty-five volts. The total horse power of this plant is about 1,500.

In the Hall process, alumina is dissolved in a fused bath of the double fluoride of aluminum and potassium, or of aluminum or sodium. The salts are mixed in a proportion corresponding to the formula $K_2Al_2F_8$ (Al_2F_6.169.KF.116). An excess of the potassium salt will increase the solvent power of the bath, but decrease its fusibility. A larger quantity of alumina fluoride renders the bath more fusible, but diminishes the alumina dissolved. The operation is conducted in iron 'tanks arranged in series. They are lined with carbon, and form the negative electrodes or cathodes. The positive electrodes or anodes are carbon rods, 3 in. diameter, attached by ⅝ in. copper rods to the conductors or leads by means of suitable clamps. The current of 5,000 amperes and 50 volts in one series and of 2,000 amperes and 20 volts in the other series is turned on. The mixture of fluorides in the tanks or pots is melted by the heat generated by the resistance they offer to the current. In about two hours' time the mixture becomes fluid, and alumina is added. The resistance of the electrolyte falls from 15 to about 8 volts, and electrolysis commences, the liberated aluminum sinks to the bottom of the tank, the oxygen going to the positive electrode, combining with the carbon, and escaping as CO_2. During the operation the bath is kept covered with fine carbon dust, and on this is placed the powdered alumina. When the voltameter indicates a rising resistance, the attendant stirs in more alumina from the surface of the pot, the carbon dust rises again to the surface, when fresh alumina is placed upon it. The metal produced is dipped out with cast iron ladles, any entangled electrolyte being skimmed back into the pot. The operation is a continuous one. The metal produced by this process is very pure. The first "run" of metal carries with it all the iron and silicon of the electrolyte, the only remaining sources of impurity being the alumina added, and the ash of the carbons which are consumed in proportion of a little less than weight of carbon to weight of metal produced.

The electrical energy expended is calculated at 22 E. H. P. per hour per pound of aluminum.

Aluminum." Aluminum is given the most exaggerated properties, and much harm .is done to the real value of the metal.

What are the facts, to begin with? Aluminum can never possibly take the place of iron and steel for structural purposes, such as in bridges and heavy machinery; it is not a rigid metal; a bar supported on bearings 24 in. apart was deflected $\frac{5}{64}$ in. with 100 lb. load, $\frac{41}{64}$ in. with 200 lb., and $2\frac{11}{64}$ in. with 300 lb. The permanent set with this load was $2\frac{3}{64}$ in., showing the low elasticity; and again, although aluminum is only one-third the weight of iron, it has less than one-half the tensile strength of the best wrought iron, and only one-third that of a mild steel. These facts would prevent it ever replacing these metals in shipbuilding and for structural purposes. But aluminum is beyond all doubt one of the most valuable of metals, and is, I believe, destined to displace almost entirely some of our older metals, for instance, copper, which its superior power in resisting corrosion, its great lightness, will enable it to replace in light machinery and fittings, gas and water fittings, steam pipes, electrical machinery. It would also be invaluable for all art work and decorative purposes. Aluminum plating would supersede both tin and nickel plating; it would largely take the place of tinned ware and German silver and electro-plate for table ware. It would also be invaluable to the chemist for many of his laboratory fittings, replacing brass and iron, which corrode so rapidly in such atmospheres. Now, bringing this paper to a close, I regret its imperfect character arising from its being put together amid pressure of other duties. I hope at some future time to bring before you a further account of the development and uses of this valuable and beautiful metal.

Mr. Dagger, replying to Dr. Kohn's question regarding the liberation of fluorine by decomposition of the cryolite, and the part it played in the process, said that in the operation as described no fluorine was liberated. The alumina was decomposed by the electric current, and the action of the fluoride seemed to be merely that of a flux when comparatively small quantities of fluoride were used. If, however, those proportions were departed from, and the pot was allowed to get out of "ore," or alumina ceased to be

COMPARISON OF ALUMINIUM WITH IRON AND COPPER.

	Aluminium.		Iron.		Steel.	Copper.	
	Cast.	Rolled.	Cast.	Wrot.		Cast.	Rolled.
Colour	Bluish white.		White.	Grey.	..	..	..
Density	2·5	2·7	7·5	7·1—7·8	7·7—7·2	8·96	
Weight per cubic foot in pounds	162		450	485	490	555	
Melting point	1,300° F.	..	2,780° F.	above 4,000° F.	4,000° F.	1,900° F.	
Tensile strength in pounds per square inch.	20,000 to 25,000.	30—35,000	15,680 lb. (7 tons)	45—60,000 (19—27 tons)	60—90,000 (40—45 tons)	20,000 (does not cast as well as Al.)	30—40,000 lb.
Elongation per cent.	15	3·0	..	7—22	5—15	..	20—40
Specific heat*	0·218	..	·1138	..	..	·0952	..
Electrical conductivity	34·0	..	16		..	99	
†Thermal conductivity	33·7	..	11·9		..	75	

* Higher than any metal except lithium and glucinum.
Al.—Atomic weight, 27·4, sp. heat equal weights, 0·2143, sp. heat atomic weights, 5·87.
Li.—Atomic weight, 7, sp. heat equal weights, 0·9408, sp. heat atomic weights, 0·59.
† Ag. = 100.

Properties of Aluminum.—The pure metal, free from silicon and iron, is said to be perfectly white, but as produced it has a bluish-white tinge. When burnished it is exceedingly beautiful; under all ordinary conditions it is unacted upon by air and moisture, sulphureted hydrogen, ammonium sulphide, and cold dilute sulphuric acid have practically no action on it, when free from silicon. The non-corrodibility, however, depends entirely upon the freedom of the metal from silicon and iron It is not affected by cold nitric acid, and only slowly when heated. The organic acids and salts, as acetates, tartrates, and citrates, have practically no corrosive action on it; though in presence of salt action is set up, though very much less than in the case of copper or tin. The salts of aluminum formed are also non-poisonous, and this would make it valuable for cooking utensils, tins, and cases for preserved foods and meats, etc. Another point in its favor is that following on its high specific heat, it takes much longer for the internal heat to penetrate an aluminum vessel, and so food heated in an aluminum pan would keep warmer for a longer time. If a plate of aluminum be heated and then withdrawn from the fire, it will retain its heat for a sufficient time to cook an egg. Its lightness, too, would make it the ideal metal for travelers' and soldiers' equipments, water bottles, canteens, etc. It would also be most valuable for surgical instruments and tubes.

It is extremely malleable, following after gold in this respect, and may be drawn into fine wire. It can be rolled into sheets about 0·0007 in. thickness, and drawn, spun, and stamped. It, however, becomes hard by working, and requires frequent and careful annealing at low temperatures; the best temperature for working is 100 deg. to 150 deg. C. Its hardness equals that of silver. Bars of the metal give a clear musical sound if struck, but the presence of even a small proportion of impurity destroys the resonance.

Castings can be made in ordinary dry sand moulds. Gates should be somewhat larger than for brass, but great care should be taken not to heat the aluminum much above the melting point, for otherwise it will absorb gases and become spongy and unsound. The shrinkage is about 2¼ per cent. of the length of the mould, and ample provision must be made for this in the cores. 100 lb. casting in Al would be equal to 290 Fe, 360 Cu, 280 Sn or Zn, 420 Ag, 48 Pb, 770 Au, 860 Pt.

Aluminum is readily corroded by alkaline solutions forming aluminates, and also by hydrochloric acid and chlorine, and is acted upon more or less by solutions of the chlorides. Very much has been written and said about the properties of aluminum, sensational leaders appear daily in the press, describing wonderful bridges and machinery, ships and houses of the aluminum age, or as one note put at the head of an article, besides which Jules Verne is dull reading, "A Dream of

added in excess, the fluoride would begin to decompose and that meant the formation of an infusible mass filling up the pot and ending the operation.

In the process conducted by the Pittsburg Co., practically nothing of this kind took place, and the run was continuous. The softening temperature of aluminum would take place between 600° and 700° F.; at that temperature it would begin to get crumbly and work a little. In contact with most other metals aluminum in presence of moisture oxidized. If a plate were taken and bound round with platinum wire alumina would gradually be formed at the contact. In the case of copper and iron vessels, corrosion would take place at the juncture of the two metals. For steam pipes, since the softening of aluminum occurred at a low temperature, its action would be uncertain for steam under high pressure, and would therefore not be a reliable metal to use. Out of a yield of 2 lb. of alumina containing 53 per cent. aluminum there would be a loss of about 3 per cent. of the aluminum, so that 97 per cent. of the theoretical amount would be about the yield obtained. Dr. Rawson had asked which would be the best mineral to use in the electric furnace, and he (Mr. Dagger) believed that corundum, if it could be obtained cheap, was certainly the best, having 87 per cent.—93 per cent. Al_2O_3; but for making the alloys he preferred bauxite, as it was easier to obtain and softer. Cryolite was simply used as a flux. It had been found that using cryolite as in the sodium process the quality of metal fell far short and did not repay for the trouble taken. In reply to Dr. Rawson whether bauxite reduced the amount of iron, he would point out that it was the rule now to prepare alumina from bauxite, and in that case bauxite was a far better mineral to use than corundum, but he would deal with that question at another time. About the carbons, there was rather a difficulty in obtaining them. The great trouble, as a rule, was that they were far too soft. He had found that the best were those which they had obtained from the United States from the mineral oil carbon, and was exceedingly pure, the ash going down to about 0·01 or 0·02 per cent. The carbons used were solid, and varied from 1½ in. to 3 in. or 8 in., made in sections and in plates banded together. Mr. Knight had raised the question as to soldering aluminum. It had not been properly overcome, but he (Mr. Dagger) would give him the formula, which might be of interest to others, and which he had found to give fairly good results. The difficulty in soldering arose of course from the formation of a film of unreducible oxide, which prevented the contact of the solder with the aluminum surfaces. For ordinary work the solder containing Al 6 parts, copper 4, zinc 90, would be used, but the zinc had to be free from iron. For heavy soldering a mixture of Al 12, copper 8, and zinc 80. In reply to Mr. Jones' question, aluminum had a beneficial action on iron in preventing the formation of blow-holes, and in giving sounder castings. Its action was most probably deoxidizing, and thus enabled it to destroy the oxides and various impurities which were entangled in the molten iron, and which rose to the surface, leaving a much purer and better metal underneath. He had seen it stated that aluminum lowered the melting point of cast iron, and he had himself taken it for granted and stated so in previous papers on aluminum; but from recent observations he rather doubted the statement, although given on high authority. For air baths, the trouble of aluminum softening at 600° was felt, and it was not considered a suitable metal. The action of sulphuric acid on aluminum would be slight at 55° C. In answer to Mr. Norman Tate, the action of coal gas on aluminum fittings caused no danger, and he could not say that they would be affected to any extent by the impurities contained in ordinary coal gas, certainly not to the degree to which iron fittings were corroded.

EXPERIMENTS WITH LEYDEN JARS.

EXPERIMENTS RECENTLY MADE BY DR. O. LODGE BEFORE THE PHYSICAL SOCIETY, LONDON.

THE first one was with resonant jars, in which the discharge of one jar precipitated the overflow of another when the lengths of the jar circuits were properly adjusted or tuned. The latter jar was entirely disconnected from the former, and was influenced merely by electro-magnetic waves emanating from the discharging circuit. Lengthening or shortening either circuit prevented the overflow. Correct tuning was, he said, of great importance in these experiments, for a dozen or more oscillations occurred before the discharge ceased. The effect could be shown over considerable distances. In connection with this subject, Mr. Blakesley had called his attention to an observation made by Priestley many years ago, who noticed that when several jars were being charged from the same prime conductor, if one of them discharged, the others would sometimes also discharge, although they were not fully charged. This he (Dr. Lodge) thought might be due to the same kind of influence which he had just shown to exist. The word *resonance*, he said, was often misunderstood by supposing it always had reference to sound, and, as substitutes, he thought that *symphoning* or *symphonic* might be allowable.

The next experiment was to show that wires might be tuned to respond to the oscillation of a jar discharge, just as a string could be tuned to respond to a tuning fork. A thin stretched wire was connected to the knob of a jar, and another parallel one to its outer coating, and by varying the length of an independent discharging circuit, a glow was caused to appear along the remote halves of the stretched wires at each discharge; each of the wires thus acted like a stopped organ pipe, the remote ends being the nodes at which the variations of pressure are greatest. By using long wires he had observed a glow on portions of them with the intermediate parts dark; this corresponded with the first harmonic, and by measuring the distance between two nodes he had determined the wave length of the oscillations. The length so found did not agree very closely with the calculated length, and the discrepancy he thought due to the specific inductive capacity of the glass not being the same for such rapidly alternating pressures as for steady ones. He also showed that the electric pulses passing along a wire could be caused, by tuning, to react on the jar to which it was connected and cause it to overflow, even when the distance from the outside to the inside coating was about eight inches. During this experiment he pointed out that the noise of the spark was greatly reduced by increasing the length of the discharging circuit. The same fact was also illustrated by causing two jars to discharge into each other, spark gaps being put both between their inner and outer coatings, so as to obtain "A" sparks and "B" sparks. By putting on a long "alternative path" as a shunt to the "B" spark gap, and increasing that gap, the noise of the "A" spark was greatly reduced. He had reason to believe that the "B" spark was a quarter phase behind the "A" spark, but the experimental proof had not been completed.

He next described some experiments on the screening of electro-magnetic radiation, in which a Hertz resonator was surrounded by different materials. He had found no trace of opacity in insulators, but the thinnest film of metal procurable completely screened the resonator. Cardboard rubbed with plumbago also acted like a nearly perfect screen. In connection with resonators he exhibited what he called a *graduated electric eye* or an *electric harp*, made by his assistant, Mr. Robinson, in which strips of tinfoil of different lengths are attached to a glass plate, and have spark gaps at each end, which separate them from other pieces of foil. One or other of the strips would respond according to the frequency of the electro-magnetic radiation falling upon it.

Mr. Blakesley asked whether the tuning of the resonant jars needed readjustment when the distance between their circuits was varied, for, according to theory, the mutual induction should diminish the self-induction of the primary, and cause its oscillations to be more rapid. If this was true, the method might be used for getting rapid oscillations. He also inquired whether the glow would appear in the same position on the two stretched wires if their ends were joined.

Dr. Sumpner wished to know how the resistances, inductances, and capacities of the circuits and jars were determined, and whether any evidence of irregular distribution of the charges on the tinfoil had been noted. With reference to the overflowing of a jar caused by using a certain length of discharging circuit, he asked whether the overflow did not prove the existence of a higher potential than that which originally existed between the coatings of the jar, and, if so, where did the excess energy come from?

Dr. Thompson asked if it would be possible to make a wire circuit analogous to an open organ pipe by putting sheets of metal on the ends of the wires.

Dr. Lodge, in reply, said Mr. Blakesley's suggestion was an important one, but he had not observed that any change in the adjustment was necessitated by varying the distance between the resonating circuits. Neither had he noticed any glow on wires joined to

form a single loop, but this might be possible if the wires were long enough to give harmonies.

In answer to Dr. Sumpner, he said that the capacities were difficult to determine, for with much rapid oscillation the coatings were virtually enlarged. Lord Rayleigh had shown how to calculate the inductances, and the resistances he had practically measured by his alternative path experiments. The overflow of jars he thought was caused by the charges in some way concentrating on the edges of the foil, thus causing a kind of flood tide at which the overflow occurred.

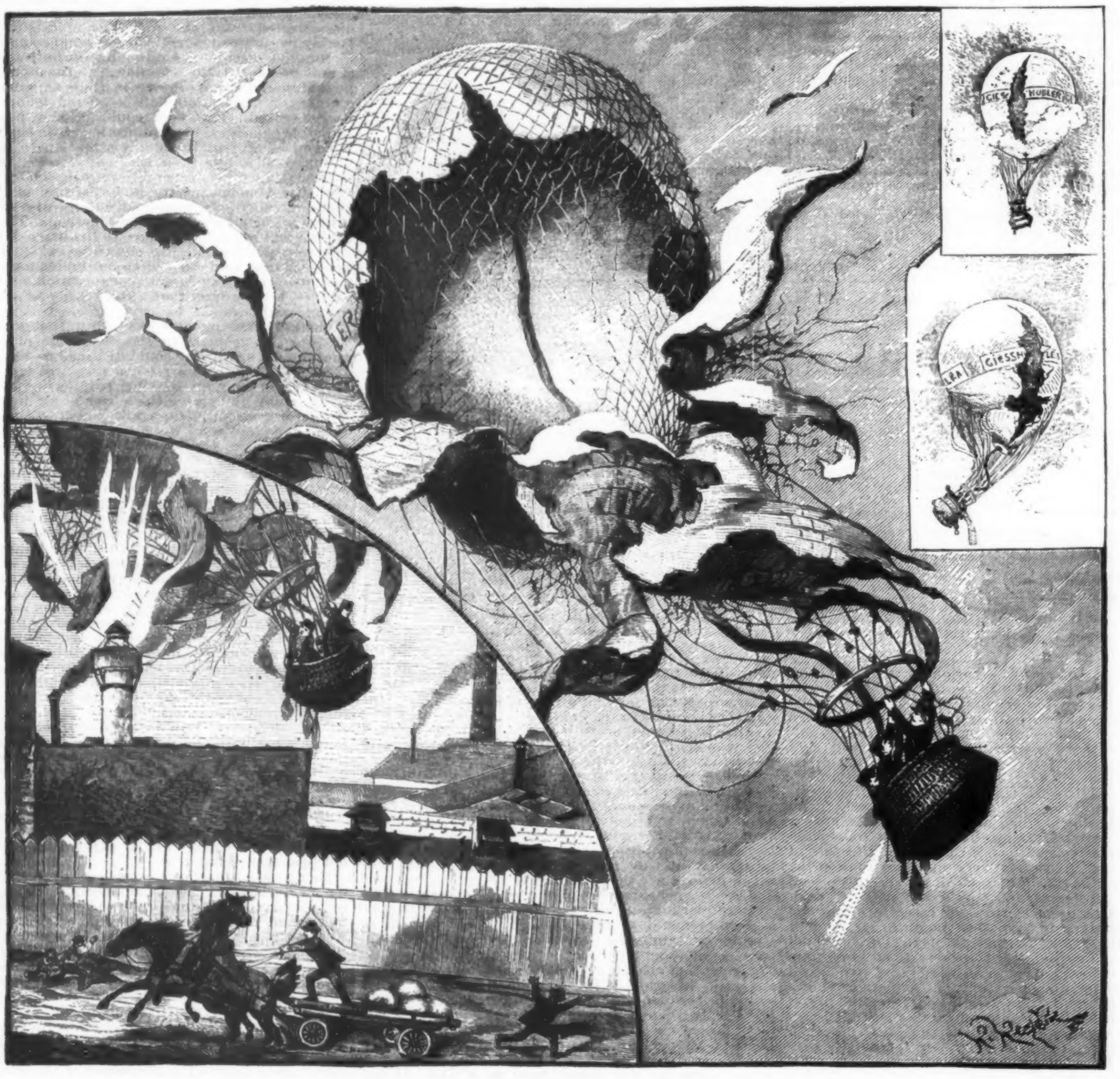
The president asked Dr. Lodge what his views were as to the cause of the opacity of ebonite to light. Was it due to a selective absorption which cut off only the rays to which the eye was sensitive, or was the ordinary explanation that it contained impurities which were conducting and hence acted as screens likely to be correct? Another possible explanation was that the motion of the ether particles may be in three dimensions, and light be due to the projection of this motion on a plane perpendicular to the ray, while electro-magnetic induction might be due to the other component.

Dr. Lodge said he believed that ebonite was not opaque, because of conducting particles being present, and was inclined to think that it acted more like ground glass, in which the opacity was due to internal reflections. Such a substance would only be opaque to vibrations whose wave lengths were comparable with the size of the particles.

A BALLOON ACCIDENT.

THE immense crowd on the grounds of the Bohemian Exposition at Bubentsch, near Prague, on June 16, was thrown into a state of great excitement by an accident which occurred above them in the air. The first free ascension of the balloon "Giesshubler" was announced for 5 o'clock in the afternoon, and hundreds had come, impelled by curiosity, to watch Capt. Wolff and his assistants prepare the balloon in which a young officer of the Prague garrison was to make the ascension with two aeronauts. When Capt. Wolff, who was not to be one of the party, gave the signal, the rope was unfastened, while the band played and the people shouted. The balloon rose majestically, every one watching it until it seemed no larger than a pear. Suddenly its form changed and it began to descend. The spectators watched breathlessly, and discovered with horror that the balloon had split from top to bottom, separating into two parts, and begun to sink rapidly. The terrible certainty that it had burst was forced upon them, and the interest become intense. In the meantime the balloon had sunk about 650 ft., and they saw that the occupants of the basket were clinging to the shreds of the balloon, trying thus to form a sort of parachute and prevent a rapid fall.

As it descended slowly the balloon was blown slightly to the south and the car began to swing so violently that it was feared the ropes would give way, precipitating the car with its occupants to the ground. Fortunately, however, this did not happen, and the spectators breathed more freely as the balloon approached; but it was not yet out of danger, for as it passed near the chimney of an iron foundry, it took fire. Lieut. Wondrusch sprang quickly to the roof of the building and helped his companions from the basket. The workmen of the factory hastened to the roof, extinguished the fire and threw the remains of the balloon to the ground. Thousands of people had gathered about the building to greet the adventurers so wonderfully saved, and to secure a piece of the balloon as a memento of the event.—*Illustrirte Zeitung.*



BALLOON ACCIDENT AT PRAGUE.

THE PURIFYING EFFECT OF SAND FILTRATION.*

By B. H. COFFEY.

THE popular idea of sand filtration is that it is a mere straining action; a partial or entire removal of suspended matter, the substances in solution remaining untouched. This, like many popular fancies, is, in the main, though not strictly, true.

Humber states that vinegar, on being passed through sand, loses most of its acid, the action gradually decreasing until the sand becomes charged, when the liquid passes unaffected. Potato brandy, diluted with water, on being passed through sand, yields first water, then water and alcohol deprived of its fusel oil, and lastly the original mixture. He also says that salt may be partly removed. This last statement is confirmed by the fact that fresh water may be obtained on almost any sea beach from a driven pump, the water, of course, filtering through the sand from the ocean. These facts are interesting, and, as far as I am aware, unexplained by theory; they would seem to show that soluble matters are removed, to a certain extent, by percolation through sand.

It is, however, with suspended matters that we have principally to deal; and here the cause and effect are very obvious.

In a polluted stream like the Schuylkill, for instance, the dissolved matters, as far as I can see, are small in quantity and, as far as health is concerned, innocuous. They consist principally of chlorine, sulphureted hydrogen, nitrogenized substances, lime, salts, and, may be, a trace of sulphuric acid and other chemicals from the numerous mills and factories that adorn its banks. These impurities, if present in large quantities, might be harmful; as it is, I know of no disease traceable to any of them.

It is the suspended matters that cause the death and destruction we hear so much of in the daily press, for among them are the germs which, modern science says, are the seeds of disease.

It will be fair to assume, then, that in the measure they are removed will be found the efficiency of sand filtration from a hygienic point of view. In the discussion of this subject, I will make three divisions: first, the theory; second, the biological and chemical results of experiment; third, the sanitary results in practice.

Theory.—The mutual attraction of floating particles is a familiar phenomenon. Two pieces of wood thrown into a tumbler of water will be drawn together. Clay, in a finely divided state in water, will deposit on the sides as well as the bottom of the vessel. In fact, I believe that the principal cause of the final deposition of the finer particles is due to this action. They are drawn together, and when the mass becomes sufficiently heavy it sinks. So powerful does the bond become, that I have been unable to reproduce the original finely divided state after subsidence, even with violent agitation. I have never heard of these facts being satisfactorily explained. I will hazard the theory that it may be due to gravity. If two bodies were placed in a perfectly frictionless medium, and all external forces eliminated, they would certainly follow the well-known law. And does it not seem that a mobile fluid like water would fulfill these conditions very perfectly? And now to return to the germs. Exactly what they are, animal or vegetable, the bacteriologists seem still in the dark. From our point of view, however, this is a matter of indifference. That they are finely divided matter no one will dispute, and being so they must necessarily follow the law we have indicated. And now, how to get rid of them.

From the above we may deduce two distinct methods, which often may be advantageously combined:

1st. To expose a relatively large depositing surface to a relatively small volume of liquid. When you consider that a cubic inch of sand particles, 0·01 inch in diameter, exposes a surface of 314 square inches to a

* Read before the Engineers' Club of Philadelphia.

cubic inch of water, you will see what a perfect medium it is for the purpose.

2d. To introduce finely divided matter into the liquid, which will attract the germs, and, in settling, carry them down. This is most perfectly accomplished by adding some precipitating agent, like alum, for instance. When this salt is added to water, carbonate of alumina is formed. It separates as a sticky, gelatinous precipitate. The particles are at first so small as to be invisible; they are quickly drawn together, however, according to our law, and, owing to their sticky property, adhere closely. They soon become heavy enough to settle, and, in doing so, carry down all suspended matter, germs included. The combination of these two methods, as it is ordinarily practiced, should certainly, on theoretical grounds, produce very good results.

I now come to the results of experiment, and will try to bore you with four-place decimals as little as possible.

The water of a polluted stream, containing many thousand germs per cubic centimeter, is found to be very much improved on entering a lake where subsidence can take place.

Dr. Percy Frankland found that a large reduction in the number of germs could be obtained by simply agitating finely divided matter with the water and then allowing it to settle. He found the action of a precipitant even more efficient. In one instance a company using Clark's lime process effected a reduction of 99 per cent.

These experiments were repeated and the results fully confirmed by Prof. Kruger, of Jena.

The results of filtration are just as satisfactory. Dr. Frankland found that the average reduction in the number of germs, effected by the London filter beds, over the original Thames water, for four months in 1885, was 98 per cent.

In the report of the State Board of Health of Massachusetts, 1888, on water supply, I find that sand filtration caused an average reduction in the albuminoid ammonia (which stands for the germs from a chemical standpoint) of about 77 per cent.

Dr. Courier, of New York, experimenting with a sand filter, employing a precipitating agent, obtained sterile water.

I could cite many other experiments, but it seems that the point that filtration will remove the germs is thoroughly established by the above.

In dealing with the actual results of purer water supply on health, I am largely indebted to Dr. E. O. Skakespeare. He states that the average deaths from cholera in Calcutta, from 1841 to 1870, were 4,000 yearly, while in 1870, after an improved supply was introduced, the number sank to 250. In the cholera epidemic of 1866, at London, the disease was confined to the locality supplied with unfiltered water. On changing the supply the epidemic ceased.

In London, the typhoid death rate for 1849 was 61·8 per 10,000; in 1866, after filtration was generally introduced, it sank to 14·4 per 10,000.

These figures are very significant and fully bear out the theoretical and experimental propositions. The deaths from typhoid in Philadelphia, Boston and New York for 1880 were respectively 1 in 1,560, 1 in 1,983 and 1 in 3,649, or a difference of 134 per cent. in favor of New York.

In 1880, London, with probably the most complete filtration system in the world, stood bottom on the list, with one typhoid death in 10,409. Philadelphia stood fourth from the top.

When you consider the polluted condition of the unfiltered Thames water, from which London's chief supply is drawn, this certainly speaks very eloquently for filtration. In the old and thickly populated countries of Europe, the conditions toward which we are rapidly approaching are already fully realized. It has been found impossible to free the water sheds of contaminating influences. The polluted water was not fit for drinking purposes, and yet these streams were the only available source of supply.

The problem has been met and solved by filtration. The principle is applied at both ends of the difficulty; the sewage is first subjected to a filtration process before entering the stream, and the water for personal use subjected to filtration before being supplied. I may say this method has become universal all over Europe. And when you consider the difference in cost of applying this method, over the only other I know of, practically banishing population from the water sheds, I think it would show a very large financial economy.

THE ARCHER AND THE CHELMON.

THE fishes have always been considered as the most degraded of the vertebrates, both as regards organization and instinctive faculties. In addition to the fact that their organs of sensibility are less perfect, and that the impressions that they receive from them are less acute and distinct, the silent and gloomy medium in which they pass their existence seems scarcely of a nature to procure very varied sensations for them. Still, as we can neither follow nor observe them in their retreats, we shall probably always be ignorant of the most interesting details of their habits. What we know of them allows us to see them (outside of the care given to the propagation of the species) solely occupied in satisfying their voracity or in securing themselves against the attacks of their enemies. It is among them especially that the struggle for existence is fierce and without mercy, and, in order to sustain it, some of them are observed to have recourse to ruses that astonish us, because they imply instincts that are much more highly developed than those that we are accustomed to meet with in this class of vertebrates.

Among the most remarkable species, from this point of view, must be mentioned, as standing in the front rank, the archer (*Toxotes jaculator*, Pallas).

The archer is a fish of the Indian Ocean, and which is met with on the coasts of Asia, of most of the islands of the Indian Archipelago, of New Guinea, and even of Australia; but it lives quite as well in fresh water. Mr. Bocourt, the conservator of the zoological galleries of the museum, has observed it in the Mé-Nam, at Bangkok, and Mr. Chaper has captured it very recently at Borneo, in the Schrœang, an affluent of the Kapoeas. This capture was made at a very great distance from the coast, beyond Sintang.

Its form is characteristic. Its head, which is quite broad, and is plane beneath, terminates in a conical snout. The eyes are large, the mouth is deeply cleft, and the lower lip is protuberant. The trunk is short and increases in width from front to rear, while at the same time it is laterally compressed. What finishes giving the animal a peculiar physiognomy is the situation, far to the rear, of the dorsal fin. The first five rays of this fin are strong spines. We may add that it is scaly, at least at the base, as is also the anal fin. Very numerous short, fine, and closely set teeth, which

FIG. 1.—THE CHELMON ROSTRATUS.

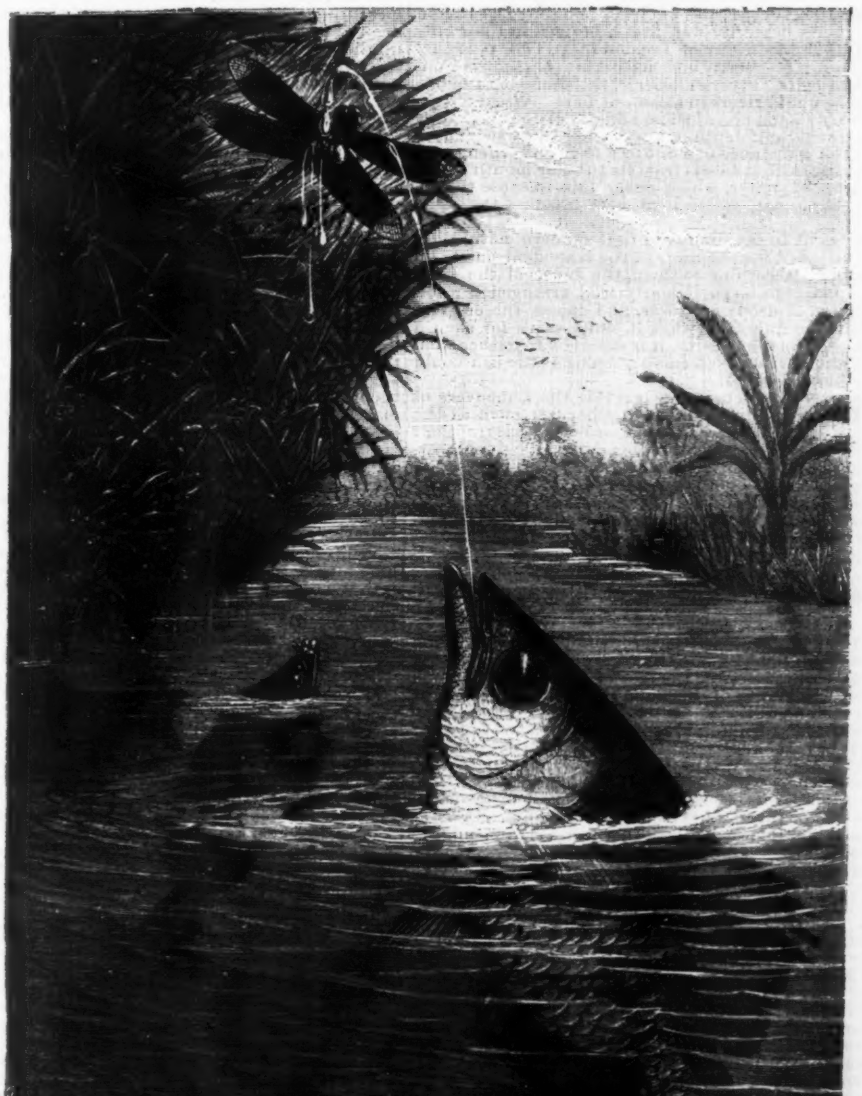


FIG. 2.—THE ARCHER—TOXOTES JACULATOR.

are called velvet teeth, and which form a sort of rasp, line the two jaws and the anterior part and sides of the palatal vault, as well as the dorsal surface of the tongue. The archer is provided with an ample, simple swimming bladder, which is rounded in front and terminates behind in a point.

The sides are greenish gray, the back is darker, and is usually provided with fine brown blotches, which descend laterally under the form of more or less distinct bands. The largest individuals attain a length of scarcely 8 inches.

The habits of this fish are very curious. It lives chiefly upon small crustaceans and insects. Cuvier mentions a specimen whose stomach was filled with ants. In order to seize insects, the archer has recourse to the following process: When it observes any flying over the water or creeping over plants, it approaches them by rising to the surface, and, striking out its head, very adroitly shoots at them from its mouth, to a height of 20 inches (some say 3 feet), a few drops of water, which, like so many projectiles, strike them and carry them along in their fall (Fig. 2). All that it has to do then is to seize the prey. If it misses the insect aimed at, it renews the attempt in a few instants, and in most cases eventually succeeds in its designs.

The archers sometimes congregate in quite large shoals, which do not permit themselves to be frightened by the approach of boats, and the disporting of which may be easily observed, as it was by Mr. Bocourt upon the Mé-Nam. It appears that the inhabitants of Java frequently keep this fish in captivity in order to amuse themselves with its maneuvers, which they bring about by putting ants and flies within its reach, on threads or sticks.

There doubtless exists a peculiar anatomical arrangement that permits the archer to spurt drops of water in this way; but, up to the present, it does not seem to have been the object of any research.

Another fish, the *Chelmon rostratus*, L., whose teeth likewise are brush-like, and whose dorsal and anal fins are scaly, as in the archer (a peculiarity that has given the name of squamipens to the fishes in which it is observed), has the reputation of resorting to the same means to procure food. It is represented of about three-quarters its natural size in Fig. 1. The almost discoidal form of the trunk, which is strongly compressed upon the sides, its snout prolonged into a tube at whose extremity is situated the mouth, in the form of a small horizontal slit, the number and arrangement of the vertical bands that extend down the sides, as well as the large round black spots, surrounded with white, observed upon its dorsal fin, suffice to distinguish it from any other species.

Like the *Toxotes*, the *Chelmon* inhabits the Indian Ocean. Its dexterity was first described in the *Philosophical Transactions* of London (A.D. 1764, p. 89), by Schlosser, a physician and naturalist of Amsterdam. "It frequents," says Schlosser, "the shores and banks of the sea and rivers in search of food. When it perceives a fly upon one of those aquatic plants that grow in water of slight depth, it approaches it, by swimming to within a distance of 4 or 5 or 6 feet, and then, with surprising skill, it spurts from its tubular mouth a simple drop of water, which never fails to cause the fly to fall to the sea, where it at once becomes the fish's prey."

We ought to say, however, that modern naturalists have disputed the accuracy of the statement made by Schlosser. According to them, the snout of the *Chelmon* appears to be particularly well arranged for the projection of drops of water, and hence the entirely gratuitous supposition that it must serve for such a purpose, while, in reality, it is designed to gather from clefts and cavities such small animals as the fish could not otherwise reach.

However it may be as regards this, the maneuvers of the *Toxotes* and those to which other fish, such as the *Diodon*, etc., have recourse in order to secure their prey, or to escape from their enemies, show that certain fishes are, from a psychical point of view, quite as well endowed as other vertebrates of higher organization, and lead to the suspicion that the fishes in general are not so wanting in this respect as our ignorance of the habits of the great majority of the species has led us to suppose.—*La Nature.*

A NATIONAL COLLECTION OF PREHISTORIC ANIMALS.

There has been prepared for the National Museum at Washington the most extraordinary collection of animals ever seen on the face of the earth, one upon which the ghosts of Barnum and Forepaugh might gaze with as wide eyed astonishment as ever the spectacle of their own united shows excited in the innocent minds of rural adolescence. In this wonderful exhibit will be gigantic reptiles as big as good sized houses, some of them 100 feet in length, flying dragons with a 25 foot spread of wings, huge birds with teeth, mammals two or three times as big as elephants, sharks as large as the hugest whales, other fishes clad in mighty plates of armor, and countless specimens more of equal strangeness and enormous dimensions, such as actually inhabited the world before man arrived in it. For nine years past the government has been digging up and putting together the skeletons of these strange creatures, and the vast collection has been stored in New Haven, Conn., previous to shipment by rail to the National Museum. The whole of it would occupy fully one-half of that institution's building.

The business of digging for these tremendous fossils is carried on pretty much like any other mining. In various parts of the West there are great deposits of them, into which the scientific enthusiasts eagerly delve for relics of epochs thousands of centuries old. One of their chosen hunting grounds is the region between the Rockies and the Wasatch Mountains. Ages ago the upheaval of these hills by geologic action cut off the portion of what had been sea between these ranges from the ocean, and the water thus shut away formed many big lakes. A typical one of this sort existed in Wyoming, and around it the mighty antediluvian mammals gathered in herds to crop the succulent and luxuriant vegetation of what was then a tropical climate in that region. They died natural deaths, or became mired in the mud when they went to drink, and the sediment slowly deposited in the water covered up their bones and preserved them from decay. This sediment reached a mile in thickness, holding between its layers these ancient skeletons, distributed like currants through a cake. At length the water draining off left the land dry, and, in the case of the Wyoming lake referred to, subsequent floods washed away much of the sediment previously deposited, leaving what are now called "bad lands," picturesque with cliffs, peaks, and columns carved out in fantastic shapes and of variegated coloring.

Through such a region as this the scientific explorer travels with his eyes as wide open for fossils as the gold hunter keeps his for the shining metal. If from the face of some rocky cliff he chances to see a bone project, exposed by the action of water that has cut away the hillside, he sets a party of men to quarrying with drill, blast and pickax, until whatever is there in the way of remains has been taken out. Possibly some great deposit of prehistoric monsters may be struck in this way, in which case the find is kept as secret as possible, being regarded by the discoverer as his private mine. If he gave it away, rival palæontologists would rush to the spot and dig out all the animals for their own study and glory. Prof. O. C. Marsh, who directed the gathering of the government collection referred to, has such mines of his own all over the West, from which he can draw to order the most astonishing variety of gigantic creatures. He made the remark the other day that there was one small valley he knew of where relics of the ancient mosasaurus were so plentiful that, passing through it recently, he noticed the skeletons of six of those mighty swimming lizards, each eighty feet in length, in sight at one time.

Usually these amazing fossils are found embedded in solid rock. After they have been roughly quarried out, the sandstone or other matrix inclosing them is carefully chiseled away from the bones. The latter receive a coat of glue to keep out the decomposing air, and any that are broken or splintered are bound up with twine, after which they are packed for shipment. When one of these beasts of antiquity died, its carcass being covered up with sediment that afterward became stone, the skeleton was apt to be preserved entire and with its parts in position, all ready for mounting in a museum. A new reptile was found in Wyoming the other day in such a complete state, which has been named brontosaurus. It was 60 ft. long, stood 15 ft. high when alive, and weighed twenty tons. Cast in the rock from which it was taken was a perfect mould of one of its eyeballs, with which it looked upon the world three millions of years ago. It had a very small head, a long and flexible neck, a short body and a huge tail. In the same neighborhood also has been discovered recently another reptilian monster called the triceratops, which had an enormous bony frill around the back of its neck. This surprising development, measuring six feet across, was intended for the attachment of great muscles that were necessary for holding up the huge head. The animal, though tremendously massive, was only thirty feet long; but it was covered with plates of armor and had a sharp and horny beak, not to mention a horn on its nose and another on its forehead, the latter 2½ ft. in length.

In Colorado have been found great deposits of the bones of titanosaurs, the biggest land animals that ever existed. They grew to be 65 ft. long and stood 40 ft. high when erect upon their hind legs. Instead of browsing, as did the brontosaur and triceratops, upon the luxuriant aquatic vegetation around the lake borders, they fed upon the foliage of trees on the mountain sides. Likewise did the iguanodon, several times as heavy as an elephant, which had a nipping beak like a turtle's and also walked erect, using its huge tail for a support and towering to the height of 40 or 50 ft.

In the mesozoic epoch, or "Age of Reptiles," when these creatures lived, these and other similar herbivorous animals were the biggest of the beasts. One of them, the atlantosaur, was 100 ft. long, its thigh bones, many of which have been found, measuring 8 ft. in length and 25 in. through. They had various methods of pursuing existence. Some went on all fours and had backbones that were mere shells filled with warm air from their lungs, which served them as floats while they walked in the sea shallows in water deep enough to cover their backs, extending their long necks to crop the vegetation alongshore. Of this sort was the camerasaurus, 80 ft. in length. Others had enormously long hind legs, on which they were able to wade out far into the ocean after seaweeds, and were provided with not fewer than 2,000 teeth for grinding their food. Such was the mighty kangaroo-like hydrosaurus. Yet other species dwelt on land, like the triceratops, and these were provided usually with armor and horns for defense.

It would seem as if such monsters as are described need have fear of no living foes, but in fact they were a common prey to great numbers of frightful carnivorous reptiles, smaller in size, but of tremendous activity and fierceness, which fed upon these unwieldy, vegetable eating giants. Most terrific of all, perhaps, was the incredibly ferocious laelaps, which was forty feet long, stood twenty-five feet high on its hind legs, and was built like a kangaroo.

It was the most astonishing jumper that ever existed, with teeth for cutting, and sharp claws on the front feet evidently designed for tearing out the eyes of victims or adversaries. Hardly less formidable and equally large was the stegosaur, which was sheathed in armor plates from two to three feet in width, and employed as a weapon of offense its powerful tail, armed near the end on both sides with sharp spikes two feet long. This animal walked erect also, and one of its peculiarities was a great enlargement of the spinal cord at the lower end of the back. In fact, this expansion of brain material, intended to provide for the wagging of the mighty spiked tail, was ten times as big as the brain in the skull itself.

Equally large and dangerous were the megalosaur and the dinosaur, their jaws armed with huge saber-like teeth, which went about on their hind legs looking for something to devour.

Against such fearful foes what chance had the peaceful cetiosaurus and elasmosaurs, dwelling in marshes and shallows, with the bulk of six or eight elephants? Nevertheless, some of the herbivorous land reptiles referred to, like the gigantic horned and armored agathumas, could make a good fight with the carnivores, and were so well able to defend themselves that they lived and multiplied in the same regions with the latter.

But most of these vegetable feeders had no other means of defense than kicking, which they could do with some effectiveness with hind legs fifteen feet or so in length.

Specimens of all these are included in the collection. Of course they represent but a few of the countless species of giant beasts that roamed over the earth in droves during this vanished epoch. That was the age when reptiles ran creation. They walked upon land, swam the seas, flew through the air, climbed trees and did everything that mammals do nowadays. There were bird reptiles and reptilian birds. Some had wings for flying with a spread of twenty-five feet—veritable dragons, in fact. Others, forty feet in length, had paddles for swimming like a whale's. These latter lived in the seas, though occasionally they came on shore.

It is known from their petrified droppings, which are plentifully found to-day, that they lived upon fish. One species dived to great depths in the ocean and was most rapacious and predatory. It had enormous eyes to see with in deep water, its head resembling an alligator's.

Another kind with a very long neck inhabited the shoals and preyed upon the fishes of the shallows. The first serpents, too, belonged in the sea, and grew to be forty feet long. They had no poison, but were constrictors, like the boa. There were many kinds of crocodiles fifty feet from snout to tail, whereas the biggest ones now are not more than fifteen feet. During the same period lived the birds with teeth, which were only discovered a few years ago. Biggest of these was the hesperornis, which stood six feet high and had only rudimentary wings. It did not fly, therefore, but was simply a swimmer and diver, subsisting on fish.

The ichthyornis was somewhat similar in appearance and habits, but not much larger than a pigeon. It is supposed that these strange water fowl were wiped out by the giant swimming lizards, eighty feet long, and clad in bony armor plates, which resemble the modern conception of the sea serpent.

The turtles should not be forgotten, which attained a length of twenty feet, and measured seven feet in height.

It is not only the age of reptiles, however, that is represented by the unparalleled collection described. Before that came the epoch of fishes, when they ran the world and had all creation pretty much to themselves. Of this era likewise the government has gathered together a vast quantity of fossil relics. The face of the earth did not look then at all as it appears now.

Most of what are now called the continents had not been upheaved above the ocean; nearly everywhere was sea, with comparatively small land masses elevated out of it. The atmosphere was hot, moist, and loaded with carbonic acid so as to be unbreathable. In the waters swam enormous armored fish, such as the dinichthys, which was fifteen feet long and had such tremendous jaws and teeth that it could have bitten a man in two as easily as you would a radish. Later on came sharks of the fiercest type, which must have been as much as seventy feet in length at least. The biggest tooth of a man eater of to-day is about an inch long, while the teeth of these ancient sharks, found in enormous numbers, measure more than six inches. That was the golden age of the scaly tribe.

The giant reptiles that appeared on the scene in the subsequent epoch were remarkable for the smallness of their brain cavities. In some of them the brain was so small that it could have been passed without injury through all the vertebræ of the spinal column down as far as the beginning of the tail. All of them were wiped out of existence by the great cataclysm which upheaved the Rocky Mountains, the Alps and the Himalayas, and brought to a close the mesozoic epoch. Then came the age of mammals, at the end of which we are now, man being the last arrival on the scene.

The age of monsters pretty nearly has passed away, only a few remaining, like the elephant and the whale. Small animals with plenty of sense will always survive stupid giants in the long run, because they require less food and know better how to avoid danger. Observe in illustration how the doom of extinction has fallen upon the gigantic mammals which roamed over the earth by myriads only so short a time ago, comparatively speaking, as the beginning of the present era, called the cenozoic.

There was the dinoceras, which lived in herds about the lakes, as the deposits show, big as an elephant, but in appearance somewhere between the rhinoceros and the hippopotamus, with three pairs of horns on its head and huge saber-like tusks that fitted into sheaths in the lower jaw.

More imposing yet was the tinoceras, somewhat similar of aspect and sixteen feet long. Not less impressive was the megatherium or giant sloth, as large as two elephants, and which attained a measurement of eighteen feet, and procured the leaves on which it fed by seating itself upon its mighty haunches and uprooting great trees.

Of the dinotherium no complete skeleton has been discovered, but it was, doubtless, the biggest land mammal that ever lived. A full grown skull of this earliest of proboscidians, which had long tusks as well as a trunk, measures five feet from the point of the lower teeth to the top of the head. The brontops of elephantine size, had a head like a rhinoceros, with huge horns.

Quite as remarkable was the sivatherium, a beast like an antelope, but big as an elephant, with two conical horns on the front of his head and two immense spreading ones behind.

Among birds were waders ten feet in height, such as the dinornis and gastornis. Contemporary with them were the mammoth and the mastodon, the woolly rhinoceros, armadillos nine feet in length, and the saber-toothed tiger, larger than the greatest lion of to-day. All that is left of these wonders of animal life is found in deposits such as those of the Western lake beds. For years the government has been engaged in excavating their bones, which are now to make part of what is to be the greatest zoological show on earth.—*Rene Bache, N. Y. Sun.*

Experiments at Cornell University show that the most and best butter cream is obtained by setting the milk in deep cans in ice water. The addition of either cold or hot water was proved to injure the cream.

CONTRACTION ON SOLUTION.

LECTURE EXPERIMENTS ILLUSTRATING PROPERTIES OF SALINE SOLUTIONS.

By Prof. J. G. MACGREGOR, Dalhousie College, Halifax, N. S.*

(1.) IN a paper printed in the last volume of this Institute's Proceedings,† I pointed out that, according to Kohlrausch's observations, sufficiently dilute solutions of sodium hydroxide have volumes which are less than the volumes which their solvent water would have in the free state, one gramme of a solution containing about six per cent. of the hydroxide having a volume 0·0045 cu. cm. less than the water it contains. Several other substances are known which exhibit the phenomenon of contraction on solution, in a similarly marked manner, but none which exhibit it to such an extent. This hydroxide, therefore, affords the best means of exhibiting the phenomenon of contraction by a lecture experiment.

The simplest mode of conducting the experiment is to pass the powdered caustic soda, little by little, down a glass tube forming a prolongation of the neck of a large bottle, the bottle and part of the tube having been first filled with distilled (or, indeed, undistilled) water. The substance is quickly dissolved by the water, the strong solution thus formed sinks and mixes with the water below, and the change of volume of the liquid is indicated by the change of height of the column of liquid in the tube. In order that the experiment may be made quickly, the powder must not be allowed to form a cake in the tube where it meets the water. To avoid this, a tube of about seven or eight mm. diameter must be used. It should be several inches in length, and should have the upper end opened out to a funnel shape, to facilitate the introduction of the powder. The tube being necessarily of large bore, the bottle must also be large, so that a small change of volume may be indicated by a comparatively large elevation or depression in the tube. The hydroxide should be in the form of a powder, not only that its solution may be accomplished quickly, but also because the solution formed must be dilute in order to secure a depression of the liquid in the tube. If it be not powdered, the substance falls to the bottom and forms a strong solution there, which only gradually diffuses into the water above. Even with a fine powder, however, a comparatively strong solution is formed at the bottom. Hence I have found it advisable to catch the powder in a wire gauze cage, attached by sealing wax to the inner end of the rubber stopper which carries the tube, and to hasten the mixture of the strong solution, formed in the tube and cage, with the water, by diverting the downward currents of the strong solution toward the sides of the bottle by means of a plate of glass hanging horizontally below the cage. If a wide-mouthed bottle be used, a stirrer may be introduced through the stopper, but leakage is thereby rendered more probable. The full amount of the contraction indicated by Kohlrausch's observations cannot, of course, be shown. For (1) the powdered caustic soda already contains a considerable quantity of water; (2) the solution of the substance is attended by a development of heat involving a rise of the liquid in the tube; (3) the powder carries air with it into the water, which must increase the volume, whether it dissolves or remains suspended; for in the latter case, if a quick effect is desired, there is not sufficient time for it to escape up the tube; and (4) whatever precautions may be taken to secure a uniform solution throughout the bottle, it cannot be at all completely secured in the time at disposal. But notwithstanding these difficulties, the experiment is a very striking one, especially if projected by a lantern on a screen. As the powdered caustic soda is passed down the tube, little by little, the liquid is seen to dissolve it without any increase in bulk, and if the substance does not already contain too much water, with an actual diminution in bulk, the level of the liquid sinking in the tube. If the powder be added in large quantity, there is a sudden rise of liquid in the tube, followed by a gradual shrinkage, which continues until the level of the liquid is lower than at the outset. The amount of the depression of the liquid in the tube is sometimes small, depending apparently upon the amount of water which the powdered caustic soda has already absorbed. The substance should not be too finely powdered, as in that case it is likely both to have taken up a considerable quantity of water and to carry down with it a considerable quantity of air. The experiment requires only a few minutes to perform.

(2.) The working hypothesis which I use when thinking of the phenomena of solution has led me to the conclusion that elevation of the temperature of a solution will have, if not identically, at any rate in a general way, the same effect on its selective absorption of light, and therefore on its color, as increase in its concentration. All the experimental evidence of which I can find any record bears out this conclusion. But, whether it holds generally or not, it may be shown, by a striking lecture experiment, to hold in the case of two salts, the chlorides of cobalt ($CoCl_2$) and iron ($FeCl_3$).

To do so, make a trough, for projection with a lantern, having thin glass sides, about the size of a lantern slide, the glass sides being one or two mm. from one another. It may readily be made by cutting a U-shaped piece from a sheet of India rubber, and cementing the glass plates to its opposite sides. Half fill the trough with a saturated solution of either salt, and fill up with a weak solution. If cobalt chloride have been used, the solution in the lower part of the trough will at ordinary temperatures be of a purplish blue, that in the upper part red; and it will be obvious that increase of the concentration of this salt involves increase of blueness in the transmitted light. If, now, a Bunsen flame be played carefully over one side of the trough, the solutions rapidly rise in temperature, and both are seen to increase in blueness, the saturated solution becoming deep blue and the weak solution purplish red.

If the iron chloride have been used, the solution in the lower part of the trough, before heating, is seen to be of a deep orange color, that in the upper part yellow; and it is obvious that increase in the concentration of this salt involves increase in redness. If, now, the flame be applied as before, the yellow solution is at once seen to become orange and the orange solution red. Owing to the narrowness of the trough and the thinness of its glass sides, sufficient heating to produce a marked change of color occupies only half a minute or so.

* From the Transactions of the Nova Scotian Institute of Science, Session of 1890-91.

† Proc. and Trans. N. S. Inst. Nat. Sci., Vol. VII. (1889), p. 363.

The same trough may, of course, be used to project the absorption spectra of these solutions on the screen. If the slit be covered half by the one solution and half by the other, both absorption spectra may be seen at once, side by side, and the gradual variation of the spectra may be watched as the trough is gradually heated.

As a means of showing the variation of the color or absorption spectrum of a solution with concentration, the above experiment has an obvious defect, viz., that the thickness of the layer of the strong and weak solutions being equal, the numbers of the salt molecules through which any ray of light passes are very different in the two cases.

It should, therefore, be supplemented by showing also the color of the spectrum obtained when the light is passed through a wide trough of the dilute solution, the ratio of the widths of the troughs being the reciprocal of the ratio of the percentages of salt in the two solutions.

(3.) Dr. W. W. J. Nicol's observation* that anhydrous sodium sulphate will dissolve in a supersaturated solution of that salt may readily be shown as a lecture experiment by projection. For that purpose place a test tube containing the solution in a trough with glass sides full of water, and focus it on the screen. Then let the anhydrous salt in the form of a fine powder fall upon the surface of solution. By taking a pinch of the powder between the thumb and forefinger (both being quite dry), it may be made to fall as a shower of fine particles. These pass into the solution and are seen to move slowly across the screen through the solution, dissolving as they go, in some cases disappearing, and often changing the concentration of the part of the solution through which they have passed, so as to produce obvious refraction effects. Finally, to show that the solution was supersaturated, add a few crystals of the hydrated salt, and crystallization at once occurs. The anhydrous salt must be added as a shower of fine powder, as larger pieces may, by taking up water and forming crystals of the hydrated salt before they can dissolve, give rise to a general crystallization of the solution.

(4.) The peculiarity of the solubility in water of such substances as anilin, carbolic acid, etc., observed by Alexejew,† may readily be shown on the screen, by using carbolic acid, whose critical temperature (the temperature above which it and water are mutually infinitely soluble) is about 69° C. For this purpose, pour some of the acid into a long test tube, of about 12 or 15 mm. diameter, and add water. The water will lie in a layer above the acid. Support the test tube by a clip grasping it at the top, and focus on the screen. The line of demarkation between the two liquids will be evident. Now mix the liquids by stirring, and the whole becomes cloudy. Let the tube stand, and the liquid separates again into two layers, having different depths from those they had before, both being now solutions. As this process requires considerable time, the stirring may have been done beforehand. Next surround the test tube by a beaker of boiling water, passing it upward from below, and stir the liquids with a hot glass rod. A slight cloudiness appears, but the liquid quickly clears and is seen to have become homogeneous throughout, the line of demarkation having disappeared. If now the beaker of hot water be removed, and one of cold water be substituted for it, the liquid becomes cloudy, a strong solution separating out everywhere, and the little spherical masses of strong solution sinking and coalescing as they sink, to form larger spheres. After a time the liquid is seen to have again become separated into two layers. If the necessary time is not available, the separation into layers may be obtained very quickly by removing the beaker of cold water and again applying the hot bath, which, raising the temperature, stops the separating out of the strong solution and redissolves it in the surrounding weaker solution, thus producing a comparatively strong solution in the lower part of the tube and a comparatively weak one in the upper part. The experiment requires but a few minutes and is both striking and instructive.

* Phil. Mag., Ser. 5, Vol. XIX. (1885) p. 453.

† Wied. Ann., Bd. XXVIII. (1886), p. 305.

SILICON FILMS.

By H. N. WARREN, Research Analyst.

IN the *Chemical News* (vol. lviii., p. 215), I published a short account of the production of silicon hydride, noting its peculiar properties; since that period recent investigations upon this and other gases have led to valuable results. Before stating the decomposition of this substance into its component parts, I will give a brief outline of the induction coil employed, which was of special construction, the core, or magnet, consisting of two pounds of chemically pure iron wire, upon which was wound about a pound of very thick copper wire, the whole being inclosed in a thick ebonite tube and filled up with pure paraffin wax. This, on being connected to a condenser of 280 sheets of tinfoil, constitutes the primary coil; over this tube was wound in 25 segments, each one being insulated from the other by means of mica disks, 9¾ lb. of No. 26 copper wire of double silk covering, the object of using so thick a grade being to increase the width of the spark in proportion to its length; the whole was now coated with paraffin, covered with thick vulcanite, and mounted. By the aid of six Bunsen batteries, a spark six inches in length and of considerable width was thus obtained, the intensity being sufficient to pierce oak planks one-quarter of an inch in thickness.

To prepare the silicon hydride, magnesium silicide was obtained by passing over metallic magnesium heated to dull redness a slow stream of silicon fluoride, until half the metal was consumed. The mass was now withdrawn from the tube and melted under a flux composed of a mixture of magnesium, potassium, and sodium chloride, a button of magnesium silicide being thus produced. This was at once introduced into an apparatus for evolving hydrogen gas, and connected to a glass tube through which passed the two electrodes in connection with the induction coil, the apparatus being cleared of the atmospheric air it contained by acting upon metallic magnesium contained therein previous to the introduction of the silicide. When the whole of the atmosphere was thus abstracted, the silicon hydride was evolved by the addition of acetic acid; the current from the coil was now turned on, amorphous silicon being at once deposited upon various parts of the glass tube, but not until the two points were in close proximity to each other did any appearance of a compact film begin to manifest itself. This, when once started, increased in length upon the withdrawal of the electrodes to a more remote distance, filling up the luminous arc and spreading out toward the further electrode; the silicon thus produced was undoubtedly absolutely pure, and when exposed to the flame of a Bunsen burner became converted into a white ash consisting of pure silica.

The gas, in admixture with coal gas, was next treated, and was readily decomposed, yielding a film consisting of a mixture of silicon and carbon. The idea of utilizing these so produced films for electro incandescent lamps was naturally one of the first prospects which presented itself; but on account of the silicon appearing mostly as amorphous, it is not sufficient to protect a carbon film over a certain time. It has nevertheless been the means, however, of carrying out an entirely different and at the same time efficient and simple process, whereby a dense silicon of peculiar formation has been so produced that several carbon films that have been thus coated have even withstood the action of the atmosphere for long durations.—*Chem. News.*

ON THE AMMONIA-SODA PROCESS.

By H. SCHREIB.

IN the year 1876 appeared a report on a proposal of Mr. Thorwald Schmidt respecting the ammonia-soda process. Mr. Schmidt proposes to decompose the liquor of the ammonia-soda process containing chlorides of sodium and calcium, by a solution of the ashes of seaweed. The sulphates of potash, soda, and magnesia contained in the ash of the seaweed are decomposed so far that hydrated sulphate of lime and hydrated magnesia are precipitated in a form which may be available for paper making, as "pearl hardening."

By further adding certain admixtures to the said liquor, at last a pure solution of chloride of sodium is obtained, while, at the same time, iodine, nitrate, and iodides are produced.

The latter solution is then treated again by the ordinary ammonia-soda process for the production of bicarbonate of soda and white alkali. The proposal of Mr. Thorwald Schmidt cannot be generally used, as the ash of seaweed is not to be had everywhere, not to count for the somewhat circumstantial way of proceeding. But the method is based upon a sound idea, viz., the permanent regeneration of the liquor by simultaneously producing useful materials.

I have become induced, by the article of Mr. Schmidt, to introduce to your readers another proceeding practically confirmed for a number of years.

My way of treating the ammonia process is, as far as I know, the only one which has been applied hitherto to practically realize the products out of the said liquor, though I must, however, remark that I have been favored by special opportunities, and that my idea of treating may scarcely be generally adopted.

A very large German manufactory, making an indispensable article for household consumption, possesses as auxiliary annex a small factory, producing per annum abont 1,000 tons of ammonia-soda required for the main works. The establishment in question requires, as well, large quantities of cardboard for packing purposes. This latter material, being of a cheap and gray colored quality, is also prepared by the same works in quantities of about 10 tons daily.

Owing to its unattractive appearance the cardboard is to be painted. I had consequently suggested to produce the required "pearl hardening" (*i. e.*, precipitated sulphate of calcium) out of the liquor of the ammonia process, in a way analogous to the one proposed by Mr. Thorwald Schmidt. But this could be done merely by adding sulphuric acid or sulphates.

When decomposing the liquid containing chloride of calcium and chloride of sodium by sulphate of sodium (Na_2SO_4), the result—

$$Na_2SO_4+CaCl_2=2NaCl+CaSO_4$$

will easily be obtained. The latter one is precipitated in connection with two molecules of crystal water, and thus forms the wanted "pearl hardening." Besides, there remains a solution of chloride of sodium which may be very well used again for the ordinary ammonia process after it has become somewhat concentrated by boiling. But, however, this course of operating has not been taken by the works in question; for the manufactory wanted to prepare, if possible, also hydrochloric acid, of which it had need in rather large quantities.

The shortest way to aim at the desired result was to decompose the liquor of the ammonia process by sulphuric acid. The "pearl hardening" was thus precipitated, and an aqueous solution of hydrochloric acid orginated therefrom. There is some common salt remaining in the solution too, but this is insignificant, and does not hinder the said proceeding.

The sulphuric acid employed for some years has now become replaced by acid sulphate of sodium, $NaHSO_4$, owing to the comparatively cheaper price of the latter article.

The weekly production of "pearl hardening," used exclusively for painting the cardboard, amounts to about 30 tons. This way of painting is a highly elaborate one, for it gives to the cardboard a brilliant gloss after it has been salined, so far that any lithographic produce may be printed directly upon the cardboard.

Nevertheless, it must be borne in mind that every manufactory will not be able to make the above described advantageous use of the liquor out of the ammonia process.

A similar proceeding may, notwithstanding, be adopted in general, provided the works will be able to combine the production of hydrochloric acid with the preparation of sulphate, viz., the first part of the soda manufacturing according to Le Blanc's method with the ammonia process. The hydrochloric acid would then be salable as usual, while the sulphate of sodium

would be left for the decomposition of the liquor containing chlorides of sodium and calcium out of the ordinary ammonia process. Pearl hardening would be precipitated, and a solution of pure chloride of sodium originated. This solution, as soon as properly concentrated by boiling, may be again treated in the ordinary way for the production of bicarbonate of soda and white alkali.

At any rate this proceeding is to be highly recommended, for it possesses the great advantage that all materials may be conserved or reproduced. There is no loss of material whatever but the trifling though inevitable one caused by the manufacturing itself.

Chlorine is obtained in the form of hydrochloric acid, except the small permanently circulating quantity. All the sodium is converted into soda, and the pearl hardening contains sulphuric acid as well as calcium. The production of hydrochloric acid through the proposed way of operating is very well worth mentioning, as the ordinary ammonia process does not admit that result.

The new proceeding can be adopted in all those places where there is a good market for pearl hardening, which I have no doubt will be the case everywhere in western Europe. Pearl hardening is a well esteemed stuff for a great many sorts of paper. It is furthermore very available for the painting of cardboard as shown above. The box makers using cardboard painted by means of pearl hardening will save any expenses for labels, etc., as all printing matter may be lithographically printed directly upon the painted cardboard, and, by the modern box making machineries, cardboard thus prepared can easily be shaped to boxes of any sort and size that will be required.

As shown by the aforesaid facts, the manufacturing of soda according to the ammonia process, even on a small scale, pays very well. The profitable realization of the returns must be taken into consideration to be sure, but, even without that good chance, the making of soda turns out most advantageously, in particular for large concerns carrying on the same in an auxiliary way in order to produce the soda required for the main works.

Owing to the soda rings driving up the prices for the article, it is worth while to keep this point in view. As far as I know, some important German makers—being large consumers of soda—are about to prepare their own ammoniated soda, in order to become independent of the fluctuations of the market.—*Chem. News.*

THE REFINING OF PETROLEUM AND LUBRICATING OILS.

PETROLEUM and lubricating oils obtained by the distillation of mineral oil are generally refined by treatment with sulphuric acid and caustic soda, followed by washing with water. Sulphuric acid at 66° B. is mostly employed, the amount used ranging from 2—4 per cent. for petroleum to 5—10 per cent. for lubricating oils. The acid is well agitated with the oil, either all at once or preferably in several installments, the acid being allowed to settle thoroughly after each treatment. The acid combines with and dissolves the olefines and aromatic hydrocarbons contained in the oil, and an oxidizing action also appears to take place, indicated by the evolution of sulphurous acid. This latter action increases with the specific gravity and temperature of the oil, so that it is well to keep the mixture cool. The time of treatment varies from 1—2 hours, the operation being finished when a sample of the oil shaken with caustic soda solution appears milky and white or only slightly yellow (petroleum), or when the original green-brown color has changed to violet-red (lubricating oil). The loss during acidification is 1—3 per cent. for petroleum, and 8—15 per cent. (seldom 20 per cent.) for lubricating oil. The oil is next washed with water and well agitated with a caustic soda solution at 30°—33° B. The intermediate washing is best omitted in the case of lubricating oils, since it leads very often to the formation of emulsions which are separated from the oil with very great difficulty. The treatment with soda is continued for 5—10 minutes at the ordinary temperature in the case of petroleum; while with the lubricating oil the action is carried on at 40°—50° C. until the violet color of the oil is changed to a wine yellow tint. The consumption of soda lye at 33° B. is abou 1—1·5 per cent. Too long a treatment with soda must be carefully avoided, in order to prevent the extensive oxidation of the oil and the consequent production of the sodium salts of organic acids. The salts are partially saponified during washing, the acid liberated being dissolved by the oil and leading to turbidity in the finished product. The oil, after being separated as completely as possible from the lye, is washed with cold water (for petroleum) or with water at 60°—70° C. (for lubricating oil) until perfectly neutral. Thorough washing is of the greatest importance. Petroleum containing sodium salts in solution burns badly, owing to the incrustation that soon forms on the wick; besides which sulphurous acid is given off, if sulphates, etc., be present. The water should be as free from dissolved salts as possible, especially for washing lubricating oils. After washing, petroleum is left in reservoirs for 12—36 hours, so that the last traces of water may settle. Or, after standing for an hour it may be filtered through a mixture of wood shavings and salt. In either case the oil will be ready for the market. Lubricating oil is kept in a vessel heated by steam until the bulk of the water has settled. It is then transferred to a shallow double bottomed pan and "boiled" by steam until it is quite bright and clear, and no longer froths. In many cases the oil is, after boiling, filtered through animal charcoal, etc.

The apparatus in which the oils are chemically treated may be divided into two groups: 1. Those in which some mechanical stirring apparatus is employed. 2. Those in which agitation is effected by a strong current of air entering the bottom of the apparatus. The author is strongly of opinion that those of the first class are much to be preferred. Agitation by means of air currents is certainly more thorough than by any mechanical device; but when the ready oxidability of petroleum, and more particularly of lubricating oil, and the injurious influence of the acids so produced, are considered, it will be seen that mechanical stirring arrangements are really the more advantageous. In the case of air agitators there is also a much greater tendency toward emulsification, which is very objectionable. The turbidity appearing in finished petroleum, etc., is chiefly due to the presence of organic acids and salts, which gradually separate. The turbidity which badly refined oil sometimes develops in barrels is most likely caused by the action of organic acids on traces of chalk contained in the glue with which the interiors of the barrels are coated. (See also this journal, 1891, 39.)—H. T P., *Chem. Zeitung.*

PURE PHOSPHORIC ACID.

M. NICOLAS, in *Compt. Rend.*, 111, p. 974, describes a method of preparation of pure phosphoric acid in which a known quantity of pure calcium phosphate is gradually added to a slight excess of pure dilute hydrofluoric acid, contained in a leaden or platinum vessel, the mixture being well stirred after each addition. An energetic action takes place and considerable heat is evolved. When all the calcium phosphate has been added, the high temperature of the mixture must be maintained for some time in order to complete the reaction. After the removal by filtration of the calcium fluoride which is formed, the solution of phosphoric acid is evaporated. At the point when the solution commences to become viscid, the excess of hydrofluoric acid used is volatilized. The evaporation is continued until a thick sirup, containing 60 per cent. to 70 per cent. of phosphoric anhydride, is obtained. Meta and pyrophosphoric acids may be prepared by further continuing the evaporation and heating. The various calcium salts of phosphoric acid described by Erlenmeyer may be readily prepared by adding hydrofluoric acid to a large excess of calcium phosphate, and after mixing well, dissolving out with warm water the acid salts produced. Impure phosphates, such as bone ash, may be used for the preparation of phosphoric acid, provided that the resultant acid, after being evaporated to carbonize the organic matters present, is diluted with water, filtered, and again evaporated.

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